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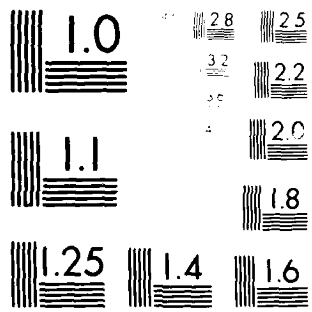

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ESTIMATION OF PARAMETERS VALUES FOR UICP DEMAND FORECASTING RULES

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OPERATIONS ANALYSIS DEPARTMENT

NAVY FLEET MATERIAL SUPPORT OFFICE
Mechanicsburg, Pennsylvania 17055

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Report 146

ESTIMATION OF PARAMETER VALUES FOR UICP
DEMAND FORECASTING RULES

PROJECT NO.
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REPORT 146

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ABSTRACT

This study estimates parameter values pertaining to the UICP (Uniform Inventory Control Program) model for forecasting demand and the MAD (Mean Absolute Deviation) of demand. More specifically, the filter constants, trend significance levels and smoothing weights are evaluated using the 5A (Aviation Afloat and Ashore Allowance Analyzer) wholesale inventory simulator. Alternative values were systematically selected for the filter constants, trend significance levels and smoothing weights to be applied to a data base of actual demands for determining which parameter values generate the most effective demand forecast. Effectiveness is judged by the following criteria: inventory investment, performance, workload and demand forecast accuracy. As a result of the simulations, the following recommendations are made:

SPCC -

- increase the filter constants (V008, V008A) from 6 and 2 to 9 and 15
- retain the current trend significance levels (V272, V272A) of 1.1 and .9
- increase the exponential smoothing weights (V273, V273A, V273B) from .3, .3 and .1 to .4, .4 and .2

ASO -

- increase the filter constants from 3 and 15 to 6 and 25
- replace the trend significance levels of 1.5 and .99 with 1.1 and .9
- retain the current exponential smoothing weights of .4, .4 and .2

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EXECUTIVE SUMMARY

1. Background. Due to increased interest by OASD (Office of Assistant Secretary of Defense) (MRA&L (Manpower, Reserve Affairs & Logistics)) in safety level computations in general and demand forecasting in particular, COMNAVSUPSYSCOM (Naval Supply Systems Command) tasked FMSO (Navy Fleet Material Support Office) to review and establish reasonable parameter values for the demand forecasting procedures used in the UICP (Uniform Inventory Control Program) to calculate the quarterly demand forecast and the MAD (Mean Absolute Deviation) of demand. The following analysis focused on the filter constants, trend significance levels and smoothing weights, since these parameters determine the quarterly demand forecast and MAD of demand.

2. Objective. To estimate parameter values for the UICP demand/MAD forecasting models.

3. Approach. The 5A (Aviation Afloat and Ashore Allowance Analyzer) wholesale inventory simulator and a data base of actual demands were used to determine the effect of alternative values for the filter constants, trend significance levels and smoothing weights. The results from the simulations of the alternative parameter values were assessed by the following criteria: $OH + $DI (dollar values of material on-hand and due-in), SMA (Supply Material Availability), ADD (Average Days Delay), PI (Procurements Initiated), RA (Repair Actions), TMSE (Total Mean Square Error) TVAD MSE (Total Value of Annual Demand Weighted Mean Square Error) and DWPE (Demand Weighted Percentage Error). These criteria were consolidated into four major categories: inventory investment ($OH + $DI), performance (SMA and ADD), workload (PI and RA),

and demand forecast accuracy (TMSE, TVAD MSE and DWPE). The parameter values which maximized the performance per dollar invested were considered the most beneficial values. Thus, the performance indices and inventory investment were the primary evaluation criteria.

Preliminary simulations were performed to determine if improvements resulted from increasing or decreasing the filter constants, trend significance levels and smoothing weights. After analyzing the results of these simulations, more specific simulations were conducted to determine how much of an increase or decrease to the parameter value was necessary to achieve the best demand forecast and MAD of demand. After determining which parameter values produced the best results, these values were simulated to quantify the impact on inventory investment and performance.

4. Findings. Substituting different values for the trend significance levels did not produce major changes in the results. However, using 1.1 and .9 for the trend significance levels did cause slight improvements. As the smoothing weights were increased, the inventory investment increased and performance improved. A moderate increase to the filter constants produced better results, but excessive increases to the filter constants resulted in long supply and higher inventory costs.

The parameter values which caused the most improvement in the performance indices per dollar invested were considered best for the purposes of this study and are shown below in TABLE I.

TABLE I

Current and Recomputed Demand Forecasting Parameter Values

Parameter	Data Element Number	SPCC Current	SPCC Recommended	ASO Current	ASO Recommended
Trend Significance Levels	V272 V272A	1.1 .9	1.1 .9	1.5 .99	1.1 .9
Smoothing Weights	V273 V273A V273B	.3 .3 .1	.4 .4 .2	.4 .4 .2	.4 .4 .2
Filter Constants	V008 V008A	6 2	9 15	3 15	6 25

Simulations were conducted using the recommended parameter values and the results were compared to the results when the current parameter values were simulated. TABLE II shows the simulated differences in inventory investment, SMA and ADD between the current parameter values and the recommended parameter values. TABLE II shows that in exchange for a slight increase in inventory investment (a decrease for 2R items) the SMA and ADD improved substantially.

TABLE II

Percentage Change in Inventory Investment and the Performance Indices Resulting from the Recomputed Parameter Values

Cog	$OH + $DI	SMA	ADD
1H	+2.6%	+9.7%	-16.7%
2H	+ .3%	+5.7%	- 6.5%
1R	+1.4%	+15.3%	-18.3%
2R	-3.9%	+7.4%	-17.6%

5. <u>Recommendations</u>. FMSO recommends that the parameter values shown in TABLE I be implemented by the ICPs (Inventory Control Points).

I. INTRODUCTION

Reference (1) requested FMSO (Navy Fleet Material Support Office) to establish reasonable and justifiable values for the various parameters used in demand forecasting and inventory levels computation. The parameters which have the most influence on the demand forecast and the MAD (Mean Absolute Deviation) of demand are: filter constants, trend significance levels and smoothing weights. The values currently used by SPCC (Navy Ships Parts Control Center) and ASO (Navy Aviation Supply Office) along with the corresponding DENs (Data Element Numbers) are shown in TABLE I.

TABLE I

Current Parameter Values

Parameter	Data Element Number	SPCC Value	ASO Value
- Filter Constants			
High Demand Consumable and all Repairable Items	V008	6	3
Low Demand Consumable Items	V008A	2	15
- Trend Significance Levels			
Upper Boundary	V272	1.1	1.5
Lower Boundary	V272A	.9	.99
- Smoothing Weights			
High Demand Trending Items	V273	.3	.4
Low Demand Trending Items	V273A	.3	.4
Nontrending Items	V273B	.1	.2

The parameters play a major part in determining demand and MAD forecasts, and also have an impact on safety level computations which are of interest to OASD (Office of Assistant Secretary of Defense) (MRA&L (Manpower, Reserve Affairs and Logistics)). The parameters were evaluated to determine which set of values generated the most improvement in the performance indices per dollar invested.

The current UICP (Uniform Inventory Control Program) demand forecasting process is documented in reference (2). The quarterly demand average (B022) and MAD of demand (A019) are computed quarterly through a sequence of three stages: (1) the filter check, (2) the trend test and (3) exponential smoothing. The first stage of demand forecasting is the filtering process which is used to exclude any abnormal data. Demand observations as recorded by the system may contain errors of one type or another. For example, a misplaced decimal could cause a demand of 10 units to be recorded as a demand of 100 units or one unit. Thus, the quarterly demand observations may be abnormally high or low compared to the current quarterly demand average.

The filtering process employed in demand forecasting was designed to act as a tolerance band around the quarterly demand average by defining the acceptable range for quarterly demand observations. When originally implemented in the UICP, the filters were set to accept quarterly demand observations that were within the interval defined by adding and subtracting three standard deviations of quarterly demand to the quarterly demand average. Thus, under the assumption of a normally distributed quarterly demand observation, a tolerance band of three standard deviations around the mean would include 95% of the quarterly demands and reject 5% as abnormal.

The filtering system described above is used for repairable and high demand (MARKs II and IV) consumable items. The specific number of standard deviations used to compute the tolerance band is determined by the filter constant. A quarterly demand observation is considered abnormal when the observation is not in the following interval:

- for SPCC, $\overline{D} - 6\sigma_D$ to $\overline{D} + 6\sigma_D$
- for ASO, $\overline{D} - 3\sigma_D$ to $\overline{D} + 3\sigma_D$

where

$\bar{D}$ = quarterly demand average (B022)

σ_D = 1.25 (MAD of quarterly demand)

When a quarterly demand observation is outside the filter limit, the values for the quarterly demand average and MAD of demand remain constant for the next quarter. However, if the quarterly demand observations are outside the same filter limit for two consecutive quarters, then the quarterly demand average is computed as the simple average of the two most recent quarterly demand observations and the MAD of demand is calculated as a function of the new quarterly demand average by the power rule equation:

$$MAD = a\bar{D}^{b}$$

where

MAD = Mean Absolute Deviation of quarterly demand (A019)

a = system demand coefficient (V004)

b = system demand power (V005)

Recomputing the quarterly demand average as the simple average of two successive high or low quarterly demand observations is known as a step increase or a step decrease. Notice that successive quarterly demand observations must be outside the same filter limit for a step increase or step decrease to occur. If the quarterly demand observation exceeds the high filter one quarter and is below the low filter the next quarter, then the quarterly demand average and the MAD of demand will remain constant.

The assumption of normally distributed quarterly demands is not considered valid for low demand (MARKs 0, I and III) consumable items. Thus, low demand consumable items are not subjected to the symmetric tolerance band filtering

system employed by high demand consumables and all repairables, but are filtered by a high limit to exclude excessive quarterly demand observations. A low filter limit is not used since quarterly demand observations of zero are acceptable for low demand consumable items. To exceed the high filter limit a quarterly demand observation must be larger than both the low demand consumable filter constant and three times the quarterly demand average. As in the case of repairables and high demand consumables, the first time a quarterly demand observation exceeds the filter limit the quarterly demand average and MAD of demand are not changed. Two successive excessive quarterly demand observations result in a step increase and the corresponding recomputation of the quarterly demand average and the MAD of demand as previously described.

Currently, the first time a quarterly demand observation exceeds the filter limit, the quarterly demand average and MAD of demand are not changed. However, the IM (Inventory Manager) is notified and has the option of recomputing the quarterly demand average and MAD of demand to include all or part of the quarterly demand observation. Recently suggestions have been made (reference (3)) to reverse this procedure and to include the filtered quarterly demand observation in the computation of the quarterly demand average and MAD of demand unless the IM manually intervenes. Thus, rather than omit the filtered quarterly demand observations and expect the IM to add back whatever is appropriate, the proposed procedure includes the filtered quarterly demand observations and expects the IM to subtract whatever amount is appropriate. The cost and effectiveness of the proposal were explored by omitting the filter checks through the use of a very large or maximum filter constant value.

Omitting the filter check reveals the cost and effectiveness for the worse case of the proposal (i.e., when the IM never intervenes with a better demand forecast).

Decreasing the filter constants causes more demand observations to be excluded from the exponential smoothing process. Thus, the quarterly demand average remains constant for more quarters. Also, the demand average is computed as a simple average of two observations and MAD is computed by the power rule more often. The opposite effects occur when the filter constants are increased.

When the quarterly demand observation is not outside a filter limit, the observation must be examined by the next stage of demand forecasting; the trend test. The trend test detects steady increases or decreases in quarterly demand observations. A trend is a tendency for quarterly demand to be biased in an upward or downward direction. There are two boundaries known as the upper trend significance level and the lower trend significance level. If the quarterly demand observation is greater than the quarterly demand average and if twice the sum of the two most recent quarterly demand observations divided by the sum of the four most recent quarterly demand observations is greater than or equal to the upper trend significance level, the quarterly demand observations are trending upward. If the quarterly demand observation is less than or equal to the quarterly demand average, and if twice the sum of the two most recent quarterly demand observations divided by the sum of the four most recent quarterly demand observations is less than the lower trend significance level, the quarterly demand observations are trending downward. The quarterly demand observations are not trending if neither of the two previous statements hold true. The following equation illustrates nontrending demand observations:

$$V272A \leq \left[\frac{2(d_t + d_{t-1})}{(d_t + d_{t-1} + d_{t-2} + d_{t-3})}\right] < V272$$

where

d = quarterly demand observation

t = index indicating time

A value of or near 1 inside the brackets [ ] signifies the demands for the past two quarters are closely related to the demand pattern over the past four quarters. The closer the value is to 1, the less trending is evident in the demand pattern. As the value becomes greater than 1, the demands are trending upward, and as the value becomes less than 1, the demands are trending downward. Notice (see TABLE I) that SPCC trend significance levels values are symmetric around 1. However, the ASO trend significance levels allow for upward flucutations, but almost no downward fluctuations before recognizing a trend.

By tightening the trend significance levels; i.e., decreasing the upper trend significance level and increasing the lower trend significance level, more demand observations are considered trending. Thus, a larger smoothing weight is used, causing more emphasis to be placed on the most recent demand observation when computing the quarterly demand average and MAD of demand. The opposite effects occur when the trend significance levels are loosened.

The final stage of demand forecasting is exponential smoothing. The exponential smoothing equations for the demand average and MAD are shown below:

$$\overline{D}_{t+1} = \alpha\, d_t + (1-\alpha)\, \overline{D}_t$$

$$MAD_{t+1} = \alpha \left| d_t - \overline{D}_t \right| + (1-\alpha)\, MAD_t$$

where

α = the smoothing weight

The weighting of the demand average components causes the demand average to "bend" in the direction of the latest quarterly demand observation. The magnitude of the "bend" is tempered by the relative magnitude of the smoothing weight, α. There are three smoothing weight parameters from which α may be selected: high demand trending items, low demand trending items and nontrending items. The Navy has used the same α value for high demand and low demand trending items for many years. This study has continued that tradition and no attempt was made to establish different smoothing weights for high and low demand trending items.

The outcome of the trend test determines which value is used as the smoothing weight in the exponential smoothing equation. When nontrending quarterly demand observations exist, a smaller α is selected for the exponential smoothing equation. Using a smaller α, increases "$1-\alpha$", which places more emphasis on the historical demand data. By placing more weight on the historical demand data, minor fluctuations which may occur in individual quarterly demand observations do not disturb the demand average. However, as the demand pattern fluctuates more drastically and trending is detected, the demand average is unable to "catch up" or reflect the actual demand pattern when a smaller smoothing weight is used. Hence, when trending quarterly demand observations exist, a larger α is used in the exponential smoothing equation. The use of the larger smoothing weight causes more emphasis to be placed on the recent quarterly demand observations so the fluctuations in the demand pattern are forecasted more accurately.

Some weight is given to all past observations in exponential smoothing. However, the older observations are continually given less weight as time passes on. After a long period of time, almost zero weight is applied to the oldest observation. As a larger smoothing weight is used, the older observations receive less weight. More specifically, when .1 is used as the smoothing weight, over 85% of the weight is given to the most recent 19 observations. When the smoothing weight is increased to .4, over 85% of the weight is given to the four most recent observations. Increasing the smoothing weight is comparable to including fewer observations in a moving average. Additional information concerning the comparison of exponential smoothing and moving average is available in reference (4).

II. TECHNICAL APPROACH

The 5A (Aviation Afloat and Ashore Allowance Analyzer) wholesale inventory simulator was used to evaluate the following parameters for demand forecasting: filter constants, trend significance levels and smoothing weights.

A. Simulation Model. The 5A simulator, as described in reference (5), replicates the inventory management operations of ASO-managed material. The 5A simulator was modified to include the changes in management policies which have occurred since the initial design, and the salient features of the S^4 (Ships Supply Support Study) CONUS (Continental United States) inventory simulator. The S^4 simulator replicates the inventory management operations for SPCC-managed material, as described in reference (6).

The revised 5A simulator consists of a series of time-oriented routines associated with the basic inventory control functions such as asset review, receipt of material from purchase and repair, levels computations and demand

forecasting. Periodically, the asset position of each item is reviewed to determine if a purchase or repair action is required. In situations where such action is required, a receipt of material from purchase or repair is scheduled to occur following a leadtime or TAT (Turn-Around-Time). Leadtimes and TATs are determined using a normally distributed pseudorandom number and the item's mean and standard deviation of leadtime or TAT.

The reorder point, economic order quantity, MAD of demand and demand average are computed quarterly. The demand forecasting routine of the 5A simulator includes the filter check, trend test and exponential smoothing as previously described and flowcharted in Appendix B.

1. Model Assumptions. The 5A simulator includes the following assumptions:

a. The initial quarterly demand forecast equals the simple average of the demand observations for the first two quarters of the demand history. The initial MAD of demand equals the simple average of the absolute values of the error terms for the first two quarters of the simulation. The error terms were computed as the difference between the quarterly demand observation and demand average. The quarterly demand average and MAD of demand must initially be assigned values because past quarterly demand averages and MADs of demand are not retained on any UICP file. That is, the quarterly demand average and MAD of demand corresponding to the beginning of the simulation period were not available and therefore were estimated.

b. The initial on-hand equals the theoretical average inventory position; i.e., initial on-hand equals the reorder level plus one-half of the order quantity. All items began with zero backorders and no orders outstanding.

c. Only the filter constants, trend significance levels and smoothing weights were adjusted for the various simulations. All other

parameters (e.g., shortage cost, minimum and maximum risk) were selected to reflect the management policy of the particular cog and remained constant throughout each simulation.

d. PPRs (Planned Program Requirements) are not modeled by the 5A simulator, but the remaining nonrecurring demands are included. Nonrecurring demands can be divided into two groups: (1) PPRs and (2) "one time" demands which do not recur. In the real world, material is procured and placed in inventory specifically to satisfy PPRs. When adequately planned, material is issued for the PPR and the requisition is counted as satisfied in the SMA calculation. For the remaining nonrecurring demands (non-PPRs), material is not procured in advance but is drawn from stock intended for recurring demands. Therefore, since nonrecurring demands use material intended for recurring demands, a lower SMA and higher ADD result.

The simulator does not process demands which are for PPRs; hence, the output statistics do not reflect these demands. The most significant area of impact is in the performance statistics. By not modeling PPRs, the simulator does not consider requisitions which are usually satisfied. Thus, the simulated SMA will be lower than in the real world, and the simulated ADD will be longer.

2. Input. The two main sources of information used for input to the 5A simulator were the THF (Transaction History File) and the SIG (Selective Item Generator) file. A data base of historical demands, obtained from the THF, were developed as input to the 5A simulator. Six years (January 1974 through December 1979) of THF demand data were used for SPCC-managed material and four years (November 1975 through October 1979) of THF demand data were used for ASO-managed material. Although the basic item

information used as input to the 5A simulator was obtained from several files, the SIG file contributed the vast majority of the item information; e.g., leadtime, TAT and unit price. The SIG file provides a snapshot of the Master Data File. A sequence of computer programs, described in reference (7), was necessary to create the simulator input.

The manner in which the input was categorized is illustrated in TABLE II.

TABLE II

Input Categorization

Cog	# Items Universe	# Samples	# Items Sample I	# Items Sample II	# Items Sample III	# Items Sample IV
1H	125,797	4	1,572	1,571	1,571	1,571
2H	11,458	3	1,636	1,634	1,631	-
1R	103,201	4	1,587	1,587	1,587	1,587
2R	22,137	1	2,892	-	-	-

The input for the 5A simulator was grouped by cogs (cognizance symbol) of material; 1H, 2H, 1R and 2R. Because the number of items per cog were so large and would consume too much computer time to simulate in entirety, several samples were formed from each of the files except for the 2R items. To achieve more confidence and precision in determining the best parameter values, several systematic random samples were selected as protection against possible error which could result from only examining one large sample. (According to Tukey's Plan, reference (8), when the results of the analysis of smaller samples are combined, the results are more representative of the universe than the results of one large sample.) Only nonprogram-related 2R items were simulated because program-related items are forecast by a four

quarter moving average as opposed to exponential smoothing. Since there were only 2,892 nonprogram-related items in the 2R item universe, all non-programmed-related 2R items were simulated.

3. Output. Statistics were tabulated and displayed after each year to evaluate the effectiveness of the parameters tested. The first two years of the simulation were treated as a transition period and were not included in the calculations of the yearly averages. The following criteria were considered the most relevant in quantifying the effectiveness of the demand forecast.

a. $OH + $DI - Dollar Value of Material On-Hand plus Dollar Value of Procurements Due-In - dollar value of inventory investment at the end of the simulated year.

b. SMA % - Supply Material Availability - the sum of requisitions satisfied immediately divided by the total number of requisitions submitted. A requisition is considered satisfied only if the entire requisition is satisfied.

c. ADD - Average Days Delay - the time delay experienced by all back-ordered requisitions divided by the total number of requisitions submitted.

d. #PI - Number of Procurements Initiated - average number of procurement orders placed during a year.

e. #RA - Number of Repair Actions - average number of repair inductions made during a year.

f. TMSE - Total Mean Square Error - a statistic which measures the accuracy of the demand forecast by averaging the square of the forecast error and summing over all the items.

$$TMSE = \sum_{i=1}^{n} \frac{\sum_{k=j+1}^{j+4} (d_{ki} - \overline{D}_{ki})^2}{4}$$

where

n = the number of items in a simulated sample

i = index of items in sample

j = index identifying the first quarter of each simulated year (0, 4, 8, 12, 16, 20)

k = index of the quarter being simulated

g. TVAD MSE - Total Value of Annual Demand Weighted Mean Square Error - a statistic which measures the accuracy of the demand forecast by weighting the square of the forecast error by the dollar value of annual demand and summing over all the items.

$$TVAD\ MSE_j = \sum_{i=1}^{n} \frac{\sum_{k=j+1}^{j+4} (d_{ki})(P_i)(d_{ki} - \overline{D}_{ki})^2}{\sum_{K=j+1}^{j+4} (d_{ki})(P_i)}$$

where

P = unit price (DEN B053)

h. DWPE - Demand Weighted Percentage Error - a statistic which measures the accuracy of the demand forecast by expressing the total absolute value of the forecast error as a percentage of the total observed quarterly demand.

$$DWPE = \frac{\sum_{i=1}^{n} \sum_{k=j+1}^{j+4} |d_{ki} - \overline{D}_{ki}|}{\sum_{i=1}^{n} \sum_{k=j+1}^{j+4} d_{ki}}$$

For ease in evaluating the effectiveness of alternative parameter values, the preceding eight criterion were combined to form four categories: inventory investment, performance, workload and demand forecast accuracy. The inventory investment was determined from the \$OH + \$DI. The SMA and ADD together were used to determine the performance of the alternative parameter values. Due to the inherent differences in the objective functions, the performance of consumable items was judged based on ADD and the performance of repairable items was judged based on SMA. The workload was measured by the #PI and #RA. The MSE, VAD MSE and DWPE were used to measure the demand forecast accuracy. Overforecasting as well as underforecasting was detected by the demand forecast accuracy statistics. Smaller results for the MSE, VAD MSE and DWPE imply a more accurate forecast. However, according to reference (9), the minimum MSE is not necessarily optimal when applied to inventory managment models. Therefore, to obtain the best performance for the least amount of money, the selection of best parameter values was based on the improvement in the performance indices per dollar invested.

B. Simulations. To determine which combination of parameter values produced the most improvement in performance per dollar invested, a RSM (Response Surface Methodology) approach was used. The first step in the RSM was identified in this analysis as the Directional Analysis. The Directional Analysis involved a series of simulations that used the current values and values which were slightly larger and smaller than the current values of the filter constants, trend significance levels and smoothing weights. The results of the Directional Analysis were analyzed to determine in which direction; i.e., larger or smaller, the parameter values generated more beneficial results. Sensitivity Analyses were then conducted for the parameters which experienced

the greatest improvements (the path of steepest ascent method) during the Directional Analysis. The Sensitivity Analyses involved a series of simulations using continually increasing or decreasing parameter values. The parameter values were increased or decreased depending on the outcome of the Directional Analysis. The recommended parameter values were selected when the most beneficial results were reached. (Additional information concerning the response surface methodology and the path of steepest ascent method is available in reference (10).)

After analyzing the results of the simulations, recommendations were made for the filter constants, trend significance levels and smoothing weights. Simulations were conducted using the recommended parameter values and compared to the results of the simulated current parameter values. The differences between the two simulations quantify the improvements generated by the recommended parameter values.

III. FINDINGS

There were three groups of simulations performed on each of the input files. The first group of simulations, which was called the Directional Analysis, showed that the filter constants and smoothing weights offered noticeable improvements to the demand forecast when the values were increased. Therefore, two additional groups of simulations were conducted: The Filter Constants Sensitivity Analysis and the Smoothing Weights Sensitivity Analysis. The Filter Constants Sensitivity Analysis consisted of simulations using progressively increasing values for the filter constants. The Smoothing Weights Sensitivity Analysis pertained to simulations using progressively increasing values for the smoothing weights. Tightening and loosening the trend significance levels did not induce significant improvements to the demand forecast. Thus, no further evaluation of the trend significance levels was made.

As previously stated, there were several samples for 1H, 2H and 1R cogs. The tables developed from the simulations performed on each of the samples are contained in Appendix C. The tables discussed in this section show the cog averages which were computed from the samples. In Appendix D, the standard deviations of the samples are shown in the upper left portion of each entry in the tables and the average of the samples are shown in the lower right portion. As is customary for sampled data, N-1 weighting was used to calculate the standard deviations. Since the universe of nonprogram-related 2R items was used, standard deviations could not be computed. Thus, 2R items were not included in Appendices C or D.

A. Directional Analysis. The Directional Analysis was designed to determine whether a more beneficial demand forecast could be obtained by increasing or decreasing the current parameter values. The Directional Analysis consisted of a series of simulations that used the current values and values which were slightly larger and smaller than the current values of the trend significance levels, smoothing weights and filter constants.

A simulation using all of the present parameter values for SPCC was conducted and called the base case. The SPCC trend significance levels (V272/V272A) were not tightened since the present values of 1.1/.9 were so close to 1. Therefore, the values were loosened in two simulations to 1.3/.7 and 1.8/.2. The smoothing weights parameters (V273/V273A/V273B) for SPCC were increased and decreased from the present values of .3/.3/.1, to .4/.4/.2 and .2/.2/0. The filter constants parameters (V008/V008A) were also increased and decreased from the current values of 6/2, to 3/1 and 9/15.

A base case simulation was also conducted for ASO-managed items. As previously stated, the trend significance levels for ASO are not symmetric around "1" and require a larger fluctuation in the upward direction than the downward

direction before a trend is detected. In an attempt to discontinue the bias against upward fluctuations, the symmetric trend significance levels tested for SPCC-managed items were used to evaluate ASO-managed items. The smoothing weights parameters were increased and decreased from the present values of .4/.4/.2, to .5/.5/.3 and .3/.3/.1. The filter constants parameters were also increased and decreased from the current values of 3/15, to 1/2 and 6/25. The results of the Directional Analysis simulations for the 1H, 2H, 1R and 2R items are shown in TABLEs III, IV, V and VI, respectively.

To determine whether the adjusted parameter values were more beneficial than the current values, the results of each simulation were compared to the results of the simulated base case; i.e., current parameter values. The figures in TABLE VII were developed from TABLEs III through VI, and show the actual amount of increases and decreases (deltas) in the inventory investment and performance criteria. The deltas (Δ's) were obtained by subtracting the output values of the base case from the corresponding output values of the simulated alternative parameter values. For example, from TABLE III, the \$OH + \$DI value of 8.217 in the base case was subtracted from the \$OH + \$DI value of 8.247 in the simulation which used .2/.2/0 as the smoothing weights. The difference was placed in TABLE VII under the \$OH + \$DI of 1H items for the smoothing weights values of .2/.2/0. The figure .030 signifies the increase generated in the \$OH + \$DI when .2/.2/0 were used as the smoothing weights as opposed to the base case values of .3/.3/.1. A negative value in TABLE VII represents a decrease to that particular criteria and a 0 indicates that the criteria did not change. The base case values are shown on TABLE VII to give the reader an idea of the percent of change the increases and decreases represent.

TABLE III

SPCC Directional Analysis
1H Mean Values

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case	8.217	59.7	71.71	936.6	N/A	8.410	.137	.786
V272 = 1.3 V272A = .7	8.195	57.5	73.36	942.5	N/A	9.042	.147	.826
V272 = 1.8 V272A = .2	8.217	56.9	74.55	955.6	N/A	9.328	.148	.853
V273 = .2 V273A = .2 V273B = 0	8.247	57.6	74.81	970.4	N/A	8.957	.145	.935
V273 = .4 V273A = .4 V273B = .2	8.454	61.2	68.92	913.1	N/A	8.616	.137	.745
V008 = 3 V008A = 1	8.051	57.7	74.92	939.3	N/A	9.043	.141	.809
V008 = 9 V008A = 15	8.180	61.7	66.26	883.5	N/A	9.776	.137	.798

TABLE IV

SPCC Directional Analysis

2H Mean Values

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case	59.226	51.2	80.28	736.5	1426.0	1.604	6.491	.972
V272 = 1.3 V272A = .7	59.342	50.6	82.80	740.3	1452.0	1.585	6.489	.972
V272 = 1.8 V272A = .2	59.127	49.3	84.19	752.4	1479.3	1.599	6.491	1.004
V273 = .2 V273A = .2 V273B = 0	59.715	50.4	80.24	745.6	1469.1	1.774	6.490	1.315
V273 = .4 V273A = .4 V273B = .2	59.005	53.3	75.97	712.4	1381.2	1.596	6.492	.890
V008 = 3 V008A = 1	61.323	52.8	80.40	728.3	1344.2	1.606	6.491	.974
V008 = 9 V008A = 15	5[illegible].320	52.8	78.83	736.7	1445.9	1.594	6.488	.967

TABLE V

ASO Directional Analysis
IR Mean Values

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case	13.648	47.0	104.86	1290.4	N/A	32.201	.189	.814
V272 = 1.3 V272A = .7	13.967	50.1	92.75	1271.5	N/A	34.275	.172	.838
V272 = 1.1 V272A = .9	13.666	50.4	94.76	1265.1	N/A	34.289	.181	.841
V272 = 1.8 V272A = .2	14.065	47.7	100.67	1311.9	N/A	33.554	.179	.852
V273 = .3 V273A = .3 V273B = .1	12.762	42.7	109.24	1389.0	N/A	32.513	.194	.848
V273 = .5 V273A = .5 V273B = .3	13.865	53.8	89.13	1213.9	N/A	32.206	.188	.793
V008 = 1 V008A = 2	14.907	53.9	91.05	1333.0	N/A	38.813	.193	.884
V008 = 6 V008A = 25	12.961	49.5	90.43	1268.8	N/A	18.365	.189	.763

TABLE VI

ASO Directional Analysis
2R Values

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case	97.580	59.6	54.81	1227.5	3446.0	11.388	12.609	1.050
V272 = 1.3 V272A = .7	101.694	58.2	52.41	1261.5	3461.5	10.484	12.599	1.008
V272 = 1.1 V272A = .9	93.056	58.4	54.32	1261.0	3418.5	11.421	12.609	1.072
V272 = 1.8 V272A = .2	105.068	58.3	55.29	1237.5	3534.5	11.425	12.609	1.089
V273 = .3 V273A = .3 V273B = .1	107.975	57.6	55.55	1211.5	3448.5	11.993	12.611	1.136
V273 = .5 V273A = .5 V273B = .3	111.299	60.6	54.83	1242.5	3238.5	10.913	12.607	1.011
V008 = 1 V008A = 2	132.019	70.8	62.20	1184.5	2530.0	11.864	12.612	1.094
V008 = 6 V008A = 25	92.195	61.4	51.37	1276.0	3682.0	7.911	12.589	.836

TABLE VII

Directional Analysis
Deltas (Δ's)

Parameter Values		SPCC				ASO			
		1H		2H		1R		2R	
SPCC	ASO	\$OH + \$DI	ADD	\$OH + \$DI	SMA	\$OH + \$DI	ADD	\$OH + \$DI	SMA
Base Case	Base Case	8.217	71.71	59.226	51.2	13.648	104.86	97.580	59.6
V272 = 1.3 V272A = .7	V272 = 1.3 V272 = .7	-.022	1.65	.116	-.6	.319	-12.11	4.114	-1.4
-	V272 = 1.1 V272A = .9	-	-	-	-	.018	-10.10	-4.524	-1.2
V272 = 1.8 V272A = .2	V272 = 1.8 V272A = .2	0	2.84	-.099	-1.9	.417	-4.19	7.488	-1.3
V273 = .2 V273A = .2 V273B = 0	V273 = .3 V273A = .3 V273B = .1	.030	3.10	.489	-.8	-.886	4.38	10.395	-2.0
V273 = .4 V273A = .4 V273B = .2	V273 = .5 V273A = .5 V273B = .3	.237	-2.79	-.221	2.1	.217	-15.73	13.719	1.0
V008 = 3 V008A = 1	V008 = 1 V008A = 2	-.166	3.21	2.097	1.6	1.259	-13.81	34.439	11.2
V008 = 9 V008A = 15	V008 = 6 V008A = 25	-.037	-5.45	.094	1.6	-.687	-14.43	-5.865	1.8

Loosening the trend significance levels to 1.3/.7 and 1.8/.2 for SPCC produced similar results for the 1H and 2H items. There was little change in the inventory investment but the performance was worse and the workload increased. Therefore, the current values, 1.1/.9, are the best setting for the SPCC trend significance levels. Using 1.3/.7 and 1.8/.2 as the trend significance levels for ASO items caused an increase in inventory investment. The performance improved for 1R items but was poorer for 2R items. The workload increased in every case except when 1.3/.7 were used as the trend significance levels for 1R items there were fewer buys. When the trend significance levels of 1.1/.9, were simulated on ASO items, the inventory investment changed very little for 1R items and decreased significantly for 2R items. The performance (ADD) of 1R items improved by 10.10 days, but SMA decreased 1.2 percentage points for 2R items. The ADD decreased a slight .49 days for 2R items. There were fewer procurements of 1R items, however, the procurements increased and repair actions decreased for 2R items. The values 1.3/.7 and 1.8/.2 benefited ASO consumable items (1R) but were unfavorable towards repairable items (2R). Therefore, neither 1.3/.7 nor 1.8/.2 were recommended for the ASO trend significance levels since the values were so disadvantageous for repairable items. The current SPCC trend significance levels, 1.1/.9, were considered the most beneficial values for ASO because the results for the 1R items were outstanding. Although the SMA decreased 1.2 percentage points for the 2R items, the inventory investment and ADD showed improvements. Therefore, 1.1/.9 are also considered the best trend significance levels for ASO.

Decreasing the smoothing weights from .3/.3/.1 to .2/.2/0 for SPCC and from .4/.4/.2 to .3/.3/.1 for ASO, generally resulted in a more costly inventory investment, less effective performance, higher workload, and a less accurate

demand forecast. When the smoothing weights were increased from .3/.3/.1 to .4/.4/.2 for SPCC and from .4/.4/.2 to .5/.5/.3 for ASO, the inventory investment increased (except for a slight decrease in 2H items) and performance improved for all items. There were fewer procurements for the consumable items (1H and 1R) and more for the repairable items (2H and 2R).

Since the inventory investment, performance, workload and forecast accuracy suffered detrimental changes when the smoothing weights were decreased, no additional simulations were conducted with smaller smoothing weights. However, in view of the promising results (improved performance and demand forecast accuracy) from increasing the smoothing weights, more simulations were made with progressively increasing values for the smoothing weights and are discussed below under Section B.

The filter constants were decreased from 6/2 to 3/1 for SPCC and from 3/15 to 1/2 for ASO. Decreasing the filter constants generated more expensive inventory investments and higher SMA for all the items except for 1H where the inventory investment and SMA both decreased. More specifically the 2R items experienced a $34.439 million increase in inventory investment. The ADD increased for all but the 1R items which experienced a 13.81 decrease. Smaller filter constants caused more of a workload for consumable items and less for repairable items. Increasing the filter constants from 6/2 to 9/15 for SPCC and from 3/15 to 6/25 for ASO produced results which are very beneficial to the Navy Supply System. In most cases there was less money spent in return for better performance. There were less procurements for consumable items and the demand forecast was more accurate.

Decreasing the filter constants resulted in increasing the inventory investment. When the filter constants were increased, the inventory investment

decreased and performance improved. Therefore, more simulations concerning increasing the values of the filter constants were made and are discussed below under Section C.

B. Smoothing Weights Sensitivity Analysis. Since the Directional Analysis showed that increasing the smoothing weights was advantageous, the Smoothing Weights Sensitivity Analysis was designed as a series of simulations which involved progressively increasing the values of the smoothing weights. By adding increments of .1 to the current smoothing weight values, simulations were conducted for each set of smoothing weights through and including .9/.9/.7. To isolate the impact of the changes to the smoothing weights, no demands were filtered. This was accomplished by adjusting the filter constants to the maximum values (999,999,999), thereby effectively eliminating the filtering process. As previously stated, the trend significance levels were set to 1.1/.9 for both ICPs. The results of the Smoothing Weights Sensitivity Analysis simulations for the 1H, 2H, 1R and 2R items are shown in TABLEs VIII, IX, X and XI, respectively.

TABLE XII was developed from TABLEs VIII through XI to show the marginal differences between the inventory investment and performance criteria generated by the increased smoothing weights. Instead of comparing the results of each simulation to the results of the base case as in TABLE VII of the Directional Analysis, the results of each simulation were compared to the results of the previous simulation which used smoothing weights of the next lower degree; i.e., marginal analysis. For example, from TABLE VIII, the ADD value of 52.43 for the simulation which used .5/.5/.3 as the smoothing weights was subtracted from the ADD value of 49.57 for the simulation which used .6/.6/.4 as the smoothing weights. The difference was placed in TABLE XII under the ADD of 1H items for the smoothing weights values of .6/.6/.4. The figure -2.86 represents the

decrease generated in the ADD when .6/.6/.4 were used as the smoothing weights as opposed to .5/.5/.3. Similar to TABLE VII, positive values represent decreases and 0 indicates no change in the criteria. The results from the current smoothing weights for SPCC, .3/.3/.3, and ASO, .4/.4/.2, are shown in the table so the increases and decreases can be placed in proper perspective.

TABLE VIII

SPCC Smoothing Weights Sensitivity Analysis

1H Mean Values

V008A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case .3 .3 .1	9.241	63.7	58.79	846.6	N/A	10.158	.138	.885
.4 .4 .2	10.047	67.4	53.11	796.3	N/A	10.599	.137	.855
.5 .5 .3	10.828	69.2	52.43	751.2	N/A	10.971	.138	.848
.6 .6 .4	13.219	70.8	49.57	778.6	N/A	11.334	.140	.850
.7 .7 .5	14.360	71.3	48.36	1028.9	N/A	11.745	.142	.855
.8 .8 .6	15.762	73.1	45.06	1381.6	N/A	12.232	.145	.865
.9 .9 .7	16.895	74.4	45.29	1555.9	N/A	12.835	.147	.877

TABLE IX

SPCC Smoothing Weights Sensitivity Analysis
2H Mean Values
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case .3 .3 .1	59.198	54.2	75.09	736.9	1430.5	1.594	6.488	.993
.4 .4 .2	59.741	56.1	73.78	715.6	1396.8	1.585	6.488	.910
.5 .5 .3	61.041	57.3	70.98	700.6	1330.2	1.590	6.488	.891
.6 .6 .4	60.867	59.0	67.48	698.9	1282.1	1.598	6.489	.892
.7 .7 .5	62.714	62.3	63.32	729.0	1227.0	1.609	6.490	.899
.8 .8 .6	63.966	62.8	63.09	755.6	1193.7	1.622	6.491	.916
.9 .9 .7	65.048	64.9	62.27	767.5	1161.3	1.639	6.492	.934

TABLE X

ASO Smoothing Weights Sensitivity Analysis

1R Mean Values

V008/A = MAX/MAX

V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case .4 .4 .2	14.459	55.7	81.57	1197.9	N/A	20.625	.168	.841
.5 .5 .3	16.349	59.9	78.82	1106.6	N/A	21.781	.172	.844
.6 .6 .4	17.359	62.4	72.60	1046.5	N/A	22.894	.180	.850
.7 .7 .5	17.938	64.2	72.79	1002.1	N/A	24.066	.190	.857
.8 .8 .6	19.841	65.8	71.95	956.8	N/A	25.343	.202	.867
.9 .9 .7	21.662	66.3	74.88	945.4	N/A	26.862	.216	.883

TABLE XI

ASO Smoothing Weights Sensitivity Analysis

2R Values

V008/A = MAX/MAX

V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case .4 .4 .2	100.764	50.3	70.44	1289.5	3837.5	10.121	12.596	1.069
.5 .5 .3	102.907	59.4	44.99	1313.0	3744.0	10.923	12.599	1.076
.6 .6 .4	96.388	62.0	44.45	1277.5	3705.0	11.736	12.602	1.089
.7 .7 .5	114.274	61.4	57.02	1286.5	3489.0	12.594	12.605	1.103
.8 .8 .6	114.205	63.5	46.07	1279.0	3550.5	13.528	12.609	1.116
.9 .9 .7	123.031	64.6	47.40	1249.0	3435.5	14.573	12.613	1.127

TABLE XII

Smoothing Weights Sensitivity Analysis
Marginal Differences
V272/A = 1.1/.9
V008/A = MAX/MAX

Parameter Values V273/A/B: SPCC	Parameter Values V273/A/B: ASO	SPCC 1H $OH + $DI (MIL)	SPCC 1H ADD	SPCC 2H $OH + $DI (MIL)	SPCC 2H SMA	ASO 1R $OH + $DI (MIL)	ASO 1R ADD	ASO 2R $OH + $DI (MIL)	ASO 2R SMA
Base Case .3/.3/.1	N/A	8.217	71.71	59.226	51.2	N/A	N/A	N/A	N/A
.4/.4/.2	Base Case .4/.4/.2	.806	-5.68	.543	1.9	13.648	104.86	97.580	59.6
.5/.5/.3	.5/.5/.3	.781	-.68	1.300	1.2	1.890	-2.75	7.888	.4
.6/.6/.4	.6/.6/.4	2.391	-2.86	-.174	1.7	1.010	-6.22	3.481	2.6
.7/.7/.5	.7/.7/.5	1.141	-1.21	1.847	3.3	.580	.19	17.886	-.6
.8/.8/.6	.8/.8/.6	1.402	-3.30	1.282	.5	1.902	-.84	-.069	2.1
.9/.9/.7	.9/.9/.7	1.133	.23	1.082	2.1	1.821	2.93	8.826	1.1

The results of the simulations show that increasing the smoothing weights causes the inventory investment to be more expensive. While more money was spent in inventory, the performance statistics also improved as the smoothing weights were increased. There were fewer procurements for SPCC items as the smoothing weights were slightly increased. However, as the smoothing weights were increased more abruptly to .6/.6/.4 and .7/.7/.5 or greater, the number of procurements increased. The number of procurements for 1R items continued to decrease as the smoothing weights were increased. However, the decrease in procurements was more gradual when larger smoothing weights were simulated. The results of the workload for 2R items were sporadic and did not follow a noticeable pattern as the smoothing weights were increased. This reaction may be attributed to the fact that there were not several samples simulated for 2R items. For SPCC items, the demand forecast became more accurate as the smoothing weights were increased to .4/.4/.2 and .5/.5/.3. The demand forecast was less accurate and continued to become less accurate at a faster rate when the smoothing weights were increased further. Since the current smoothing weight values for ASO are .1 greater than the SPCC parameter settings, the demand forecast was less accurate after the first interval increase of the smoothing weights, and then reacted in a similar fashion to the remaining increases as the SPCC items. The Directional Analysis showed that decreasing the smoothing weights also produced a less accurate demand forecast.

Analyzing the summary results of the Smoothing Weights Sensitivity Analysis (TABLE XII) for SPCC reveals the most improvement in performance per dollar invested occurs with the .4/.4/.2 smoothing weights. For 1H items, the inventory investment increased $.806 million in return for 3.4 more percentage points SMA and 5.68 fewer ADD. The inventory investment increased $.543

million for 2H items in return for 1.9 percentage points increase in SMA and 1.31 fewer ADD. Increasing the smoothing weights any further required too high an investment for the corresponding improvements in performance. TABLE XII illustrates this especially for 1H items when the marginal differences in investment and ADD are compared between .4/.4/.2 and .5/.5/.3. Each required approximately \$.800 million more but the first \$.800 million bought a reduction of 5.68 ADD while the second \$.800 million only reduced ADD by .68. For 2R items, the inventory investment increased nearly eight million dollars but SMA increased only .4 percentage points when .5/.5/.3 were simulated as the smoothing weights. The inventory investment was more expensive as the smoothing weights were increased further. Therefore, .4/.4/.2 were the best smoothing weights evaluated for ASO.

C. Filter Constants Sensitivity Analysis. According to the Directional Analysis, larger filter constants produced more beneficial results than the current filter constants. Thus, the Filter Constants Sensitivity Analysis was designed as a series of simulations which dealt with progressively increasing the filter constants to the maximum values. Since the previous analyses have shown the best trend significance levels were 1.1/.9 and the best smoothing weights were .4/.4/.2, these values were used for the Filter Constants Sensitivity Analysis. The current filter constants for SPCC are 6/2 and for ASO are 3/15. The alternative filter constants which were simulated for SPCC were 9/15, 15/30, 25/100 and maximum/maximum; i.e., 999,999,999/999,999,999. The values simulated for the filter constants for ASO were 6/25, 15/30, 25/100 and maximum/maximum. The results of the Filter Constants Sensitivity Analysis simulations for 1H, 2H, 1R and 2R items are shown in TABLEs XIII, XIV, XV and XVI, respectively.

TABLE XVII was developed from TABLEs XIII through XVI to show the marginal differences between the inventory investment and performance results generated by the increased filter constants. Similar to TABLE XII in the Smoothing Weights Sensitivity Analysis, the results of each simulation were compared to the results of the previous simulation which used the next smaller value for the filter constants.

TABLE XIII

SPCC Filter Constants Sensitivity Analysis
1H Mean Values
V273/A/B = .4/.4/.2

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case 6/2	8.455	61.2	68.92	913.1	N/A	8.616	.137	.745
9/15	8.427	65.5	59.77	832.9	N/A	10.072	.137	.762
15/30	8.626	64.5	59.77	819.2	N/A	10.021	.137	.762
25/100	8.610	64.8	57.01	805.3	N/A	10.151	.137	.782
MAX/MAX	10.047	67.4	53.11	796.3	N/A	10.599	.137	.855

TABLE XIV

SPCC Filter Constants Sensitivity Analysis
2H Mean Values
V273/A/B = .4/.4/.2

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case 6/2	59.005	53.3	75.97	712.4	1381.2	1.596	6.492	.890
9/15	58.975	54.3	74.51	763.8	1388.4	1.584	6.488	.839
15/30	59.497	55.6	72.71	764.1	1376.7	1.585	6.488	.895
25/100	59.455	55.5	72.54	765.2	1382.8	1.585	6.488	.900
MAX/MAX	59.741	56.1	73.78	715.6	1396.8	1.585	6.488	.910

TABLE XV

ASO Filter Constants Sensitivity Analysis
1R Mean Values
V272/A = 1.1/.9

PARAMETER VALUES V008	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case 3/15	13.711	50.4	94.76	1265.1	N/A	34.289	.181	.841
6/25	14.051	52.5	86.39	1213.3	N/A	20.268	.166	.802
15/30	14.473	56.3	83.15	1230.8	N/A	20.463	.167	.808
25/100	14.459	56.2	79.82	1203.4	N/A	20.454	.167	.817
MAX/MAX	14.458	55.7	81.57	1197.9	N/A	20.625	.168	.841

TABLE XVI

ASO Filter Constants Sensitivity Analysis
2R Values
V272/A = 1.1/.9

PARAMETER VALUES V008	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	TMSE (MIL)	TVAD MSE (MIL)	DWPE
Base Case 3/15	93.056	58.4	54.32	1261.0	3418.5	11.421	12.609	1.072
6/25	93.751	64.0	45.17	1257.5	3709.0	7.935	12.588	.860
15/30	94.789	60.2	48.65	1288.5	3847.5	7.872	12.587	.875
25/100	90.320	62.3	52.39	1282.0	3750.5	7.872	12.587	.877
MAX/MAX	100.764	50.3	70.44	1289.5	3837.5	10.121	12.596	1.069

TABLE XVII

Filter Constants Sensitivity Analysis
Marginal Differences
V272/A = 1.1/.9
V273/A/B = .4/.4/.2

Parameter Values V008/A		SPCC				ASO			
		1H		2H		1R		2R	
SPCC	ASO	\$OH + \$DI (MIL)	ADD	\$OH + \$DI (MIL)	SMA	\$OH + \$DI (MIL)	ADD	\$OH + \$DI (MIL)	SMA
Base Case 6/2	Base Case 3/15	8.455	68.92	59.005	53.3	13.711	94.76	93.056	58.4
9/15	6/25	-.028	-9.15	-.030	1.0	.340	-3.88	.695	5.6
15/30	15/30	.199	0	.522	1.3	.422	-3.24	1.038	-3.8
25/100	25/100	-.016	-2.76	-.042	-.1	-.014	-3.33	-4.469	2.1
MAX/MAX	MAX/MAX	1.437	-3.9	.286	.6	-.001	1.75	10.444	-12.0

Raising the filter constants one interval to 9/15 for SPCC and 6/25 for ASO, caused the inventory investment to decrease slightly for SPCC and increase slightly for ASO. Although the inventory investment increased nearly \$.700 million for 2R items, the percentage of increase was small, from \$93.056 to \$93.751 million (.7%). The performance improved for all four types of items. The improvements were particularly evident in 1H items, as ADD improved 9.15, and 2R items, where SMA increased by 5.6 percentage points. There were fewer procurements for consumable items, but the workload for repairable items increased. Although there were 290.5 more repair actions for 2R items, the percentage of increase was not very drastic, from 3418.5 to 3709.0 (8.5%). The demand forecast was more accurate for all items except 1H. Increasing the filter constants further to 15/30 was more expensive for all the items and at the same time 1H and 2R items suffered poorer results in performance. The filter constants values of 25/100 produced a slightly less expensive inventory investment, but again several performance statistics experienced setbacks. When the maximum values were used as the filter constants, the 1H and 2R items were very expensive to manage and many performance statistics were poorer when compared to the results from 25/100.

A small increase to the filter constants resulted in the most favorable improvement in performance per dollar invested. A considerable improvement in performance was noticed in all items as the inventory investment decreased slightly for SPCC items and increased slightly for ASO items. A more drastic increase to the filter constants can be more expensive and less advantageous for the supply system. Therefore, the best filter constants are obtained when the filter constants are increased from 6/2 to 9/15 for SPCC and from 3/15 to 6/25 for ASO.

Eliminating the filtering process by using extremely large filter constants is not a sound practice for the supply system. For example, if several very small demand observations were recorded for an item with ordinarily high demand, the demand average would be computed as an unusually small value. Therefore, fewer items would be purchased for the inventory. Then if the item would return to the higher demand pattern, there would not be enough inventory to supply the demand, thus creating backorders. If there was a filterming system, the unusually small demand observations would not have been included in the computation of the demand average. The opposite type of reaction can also be avoided by the filtering process. If very large demand observations were recorded for an item which normally has a small demand, the demand average would be computed as an unusually large value. This would generate many larger buys for the inventory of the item. Then as the demand pattern becomes small again, the inventory position would be in long supply and disposal would be necessary.

Reference (3) suggested to reverse the filtering process and give the inventory manager the responsibility of excluding any unwanted quarterly demand observations. Each inventory manager maintains many items and at times are extremely burdened when special programs such as stratification are due. During these periods an inventory manager may mistakably not exclude a quarterly demand observation from the quarterly demand average. This may cause a situation as explained in the previous paragraph. Therefore, the suggestion of reference (3) is not recommended for implementation.

The poorest case of the reverse filtering process described in reference (3); i.e., not allowing any inventory manager intervention and including all quarterly demand observations in the computation of the quarterly demand

average, is illustrated by increasing the filter constants to their maximum values. When the maximum filter constants were used for SPCC instead of the recommended filter constants of 9/15, the inventory investment increased by $1.620 million for the 1,571 1H items simulated. If the maximum values were implemented for all 1H items, the increase in inventory investment would be much greater. Using the maximum filter constants for ASO instead of the recommended values of 6/25, increased the inventory investment for 2R items by $7.013 million.

D. Simulated Current vs. Recommended Parameter Values. Based on the results of the Directional Analysis, Smoothing Weights Sensitivity Analysis and Filter Constants Sensitivity Analysis, the best trend significance levels, smoothing weights and filter constants were determined and are shown in TABLE XVIII.

TABLE XVIII

Recommended Parameter Values
for Demand Forecasting

Parameter	Data Element Number	SPCC		ASO	
		Current	Recommended	Current	Recommended
Trend Significance Levels	V272 V272A	1.1 .9	1.1 .9	1.5 .99	1.1 .9
Smoothing Weights	V273 V273A V273B	.3 .3 .1	.4 .4 .2	.4 .4 .2	.4 .4 .2
Filter Constants	V008 V008A	6 2	9 15	3 15	6 25

The preceding analyses have shown that the best trend significance levels are the current SPCC values, 1.1/.9, and the best smoothing weights are the current ASO values, .4/.4/.2. The filter constants were increased to 9/15 for SPCC and 6/25 for ASO.

Simulations were conducted using the recommended parameter values and compared to the simulations of the current parameter values; i.e., base case. TABLE XIX and XX show the results of the simulations for SPCC and ASO, respectively. The standard deviations for the samples are shown in the upper left portion of each entry in the table and the means of the samples are shown in the lower portion.

The difference between the criteria of the simulated recommended parameter values and the simulated current parameter values was obtained by subtracting the output of the current parameters from the recommended parameters. The difference represents an increase (positive value), decrease (negative values), or no change (0) generated in the criteria as a result of using the recommended values as opposed to the current values.

The results in TABLEs XIX and XX show that the recommended parameters produced a very slight increase in inventory investment for all but the 2R items where a $3.829 million decrease was observed. Both performance criteria, SMA and ADD improved greatly for all of the items. There was less of a workload for all items except for 2R. The decrease in workload was particularly evident for 1H items where there were 103.7 fewer procurements when the recommended parameters were used. Although there were 263.0 more repairs for 2R items, the percentage of increase was rather small, from 3446.0 to 3709.0 (7.5%). The demand forecast appeared more accurate because all three forecast

accuracy statistics improved for every cog except 1H. In general, the recommended parameter values produced slightly more expensive inventory investments in return for greatly improved performance, smaller workload and more accurate demand forecasts.

TABLE XIX

Simulated Recommendations
SPCC

COG	PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	DWPE
1H	Recomputed Parameter Values	7.106 / 8.427	2.5 / 65.5	9.36 / 59.77	39.4 / 832.9	N/A	11.408 / 10.072	.115 / .137	.129 / .762
1H	Current Parameter Values	7.324 / 8.217	2.8 / 59.7	6.43 / 71.71	36.7 / 936.6	N/A	8.162 / 8.410	.115 / .137	.138 / .786
1H	Difference	.210	5.8	-11.94	-103.7	N/A	1.662	0	-.024
2H	Recomputed Parameter Values	27.290 / 59.395	2.7 / 54.1	5.22 / 75.10	10.2 / 716.4	86.6 / 1395.4	2.306 / 1.584	11.184 / 6.488	.164 / .887
2H	Current Parameter Values	26.609 / 59.226	3.1 / 51.2	6.98 / 80.28	9.5 / 736.5	99.6 / 1426.0	2.310 / 1.604	11.182 / 6.491	.182 / .972
2H	Difference	.169	2.9	-5.18	-20.1	-30.6	-.020	-.003	-.085

TABLE XX

Simulated Recommendations
ASO

COG	PARAMETER	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	DWPE
1R	Recomputed Parameter Values	2.990 / 13.843	4.9 / 54.2	7.43 / 85.72	57.6 / 1239.4	N/A	18.942 / 20.428	.105 / .168	.048 / .798
1R	Current Parameter Values	4.529 / 13.647	2.0 / 47.0	5.65 / 104.86	59.2 / 1290.4	N/A	45.524 / 32.201	.112 / .189	.146 / .814
1R	Difference	.196	7.2	-19.14	-51.0	N/A	-11.773	-.021	-.016
2R	Recomputed Parameter Values	93.751	64.0	45.17	1257.5	3709.0	7.935	12.588	.860
2R	Current Parameter Values	97.580	59.6	54.81	1227.5	3446.0	11.388	12.609	1.050
2R	Difference	-3.829	4.4	-9.64	30.0	263.0	-3.453	-.021	-.190

Confidence intervals were constructed about the results of the simulated current and recommended parameter values in TABLEs XIX and XX to determine whether the differences between the two sets of simulations were statistically significant. The following formula was used to calculate the confidence intervals:

$$\overline{X} \pm t\ S/\sqrt{N}$$

where

$\overline{X}$ = the mean value of the samples

t = the Student's value at the 90% level of confidence; 2.353 for four samples (1H and 1R) and 2.920 for three samples (2H)

S = the standard deviation of the samples

N = the number of samples

Since the inventory investment and performance were the most important criteria used to judge the simulations, confidence intervals were computed about the \$OH + \$DI, SMA and ADD. When the confidence intervals for the same criteria overlapped for a particular cog, the differences between the simulated current and recommended parameter values were minimal. If the confidence intervals did not overlap, the differences in the output criteria were considered statistically significant. The confidence intervals which were computed from the \$OH + \$DI, SMA and ADD statistics in TABLEs XIX and XX are shown in TABLE XXI.

TABLE XXI

Confidence Intervals

		\$OH + \$DI	SMA %	ADD
1H	Recommended	.067 - 16.787	62.6 - 68.4	48.76 - 70.78
	Current	-.040 - 16.834	56.4 - 63.0	64.15 - 79.27
2H	Recommended	19.552 - 99.238	50.2 - 58.0	67.48 - 82.72
	Current	20.377 - 98.075	46.7 - 55.7	70.09 - 90.47
1R	Recommended	10.325 - 17.361	48.4 - 60.0	76.98 - 94.46
	Current	8.319 - 18.975	44.6 - 49.4	98.21 - 111.51

Since the confidence intervals for the \$OH + \$DI overlap, no statistical difference exists between the inventory investment required by the current and recommended parameter values. The confidence intervals for the SMA and ADD of the consumable items overlap very little or not at all. Thus, the performance statistics for the recommended parameter values are significantly better. Overlapping is evident in the performance statistics for 2H items. However, since the confidence intervals do not overlap totally, a slight improvement may occur in the performance of 2H items by using the recommended parameter values. Therefore, the results of the confidence intervals reveal that the recommended parameter values improve the performance of the items while the inventory investment remains at approximately the same amount.

IV. SUMMARY AND CONCLUSIONS

The trend significance levels, smoothing weights and filter constants are major factors in the computation of the demand and MAD forecasts. With

the aid of the 5A simulator, several different values were systematically substituted for these parameters to determine which values provided the most beneficial demand forecast for the Navy Supply System.

A. Determining Recommended Parameter Values. The results of the simulations were judged according to inventory investment, performance, workload and demand forecast accuracy, but most of the emphasis was placed on the inventory investment and performance. The first group of simulations was identified as the Directional Analysis. The Directional Analysis was used to determine whether improvements resulted from increasing or decreasing the current parameter values. Based on the Directional Analysis, the current SPCC trend significance levels were recommended to be used for ASO and SPCC.

The Directional Analysis indicated that larger smoothing weights may improve results; therefore, the Smoothing Weights Sensitivity Analysis was designed to evaluate larger smoothing weight values. For SPCC, small increases in inventory investment and improvement in performance were observed in the initial increase to the smoothing weights. However, rather large increases in inventory investment and smaller improvements in performance were observed when the smoothing weights were first increased for ASO items. A drastic increase to the smoothing weights appears to encourage long supply since the inventory investment increases and performance improves. Therefore, a slight increase to the SPCC smoothing weights is recommended while the ASO smoothing weights are recommended to remain constant.

The Directional Analysis also indicated that larger filter constants produced better results than the current values. Therefore, the Filter Constants Sensitivity Analysis was conducted using progressively larger values for the filter constants. When the filter constants were first increased, no

significant changes in inventory investment were observed. The performance results were better for all items and the demand forecast was more accurate. As the filter constants were increased again, the inventory investment increased and several performance statistics became worse. The performance statistics continued to worsen as the filter constants were increased. Therefore, a small increase to both the SPCC and ASO filter constants was recommended.

As previously stated, reference (3) suggested to reverse the filtering process by including all quarterly demand observations in the computation of the quarterly demand average. The only manner in which a quarterly demand observation is excluded from the quarterly demand average is by manual intervention on the part of the inventory manager. The poorest case of the reversed filtering idea was illustrated when the filter constants were increased to their maximum values. By increasing the filter constants to their maximum values, no quarterly demand observations were filtered and no intervention by the inventory manager occurred. When the maximum filter constants were used instead of the recommended values, the inventory investment was much greater for 1H and 2R items.

B. Impact of Recommended Parameter Values. The recommended parameter values for the trend significance levels, smoothing weights and filter constants for SPCC and ASO are shown in TABLE XXII.

TABLE XXII

Recommended Parameter Values

Parameter	Data Element Number	SPCC		ASO	
		Current	Recommended	Current	Recommended
Trend Significance Levels	V272 V272A	1.1 .9	1.1 .9	1.5 .99	1.1 .9
Smoothing Weights	V273 V273A V273B	.3 .3 .1	.4 .4 .2	.4 .4 .2	.4 .4 .2
Filter Constants	V008 V008A	6 2	9 15	3 15	6 25

Simulations were conducted using the recommended parameter values and compared to the simulations of the current parameter values. TABLE XXIII shows the results of the simulations for SPCC and ASO. Only the most important criteria, inventory investment and performance were included in TABLE XXIII. The increases and decreases produced in the criteria are also shown to quantify the impact of the recommended parameter values.

TABLE XXIII

Simulated Recommendations

Cog	Parameter Values	\$OH + \$DI (MIL)	SMA %	ADD
1H	Recommended Parameter Values	8.427	65.5	59.77
1H	Current Parameter Values	8.217	59.7	71.71
1H	Difference	.210	5.8	-11.94
2H	Recommended Parameter Values	59.395	54.1	75.10
2H	Current Parameter Values	59.226	51.2	80.28
2H	Difference	.169	2.9	-5.18
1R	Recommended Parameter Values	13.843	54.2	85.72
1R	Current Parameter Values	13.647	47.0	104.86
1R	Difference	.196	7.2	-19.14
2R	Recommended Parameter Values	93.751	64.0	45.17
2R	Current Parameter Values	97.580	59.6	54.81
2R	Difference	-3.829	4.4	-9.64

The confidence intervals for the statistics of TABLE XXIII showed that no statistical differences existed between the inventory investments of the current and recommended parameter values for 1H, 2H and 1R items. According to the confidence intervals, the recommended parameter values produced statistically significant improvements in the performance of the consumable items, but detected only slight improvements in the performance of 2H items. As previously stated, confidence intervals were not developed for 2R items, since the universe of nonprogram-related items was simulated without sampling. However, by examining TABLE XXIII, both the inventory investment decreased and the performance improved considerably when the recommended parameter values were used. Therefore, the recommended parameter values generated improvements in the performance of all four types of items for the same amount or less inventory investment that the current parameter values required. The recommended parameter values shown in TABLE XXIII can be readily implemented in the UICP and are more beneficial to the Navy Supply System than the current parameter values.

V. RECOMMENDATIONS

FMSO recommends the parameter values shown in TABLE XXII be implemented by SPCC and ASO.

APPENDIX A: REFERENCES

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6. Ships Supply Support Study by James W. Prichard of 15 Jun 1973
7. Memorandum 9322-D65/JLZ/jas of 3 Jun 1980
8. W. E. Demming, Some Theory of Sampling, John Wiley and Sons, Inc. 1950
9. U. S. Army Inventory Research Office Report No. 263, Integrated Forecasting Techniques for Secondary Item Classes - Part I - Active Items of September 1980
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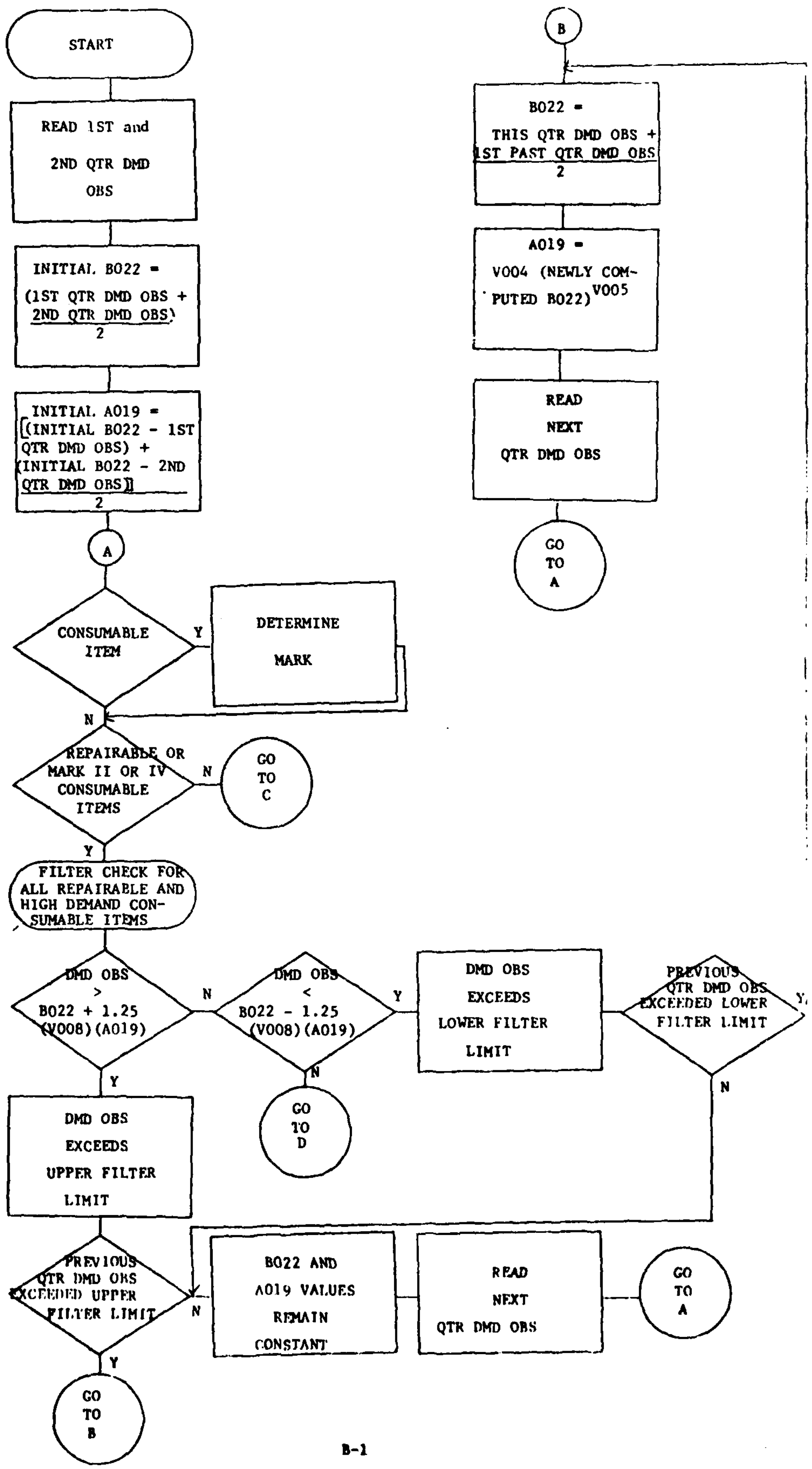
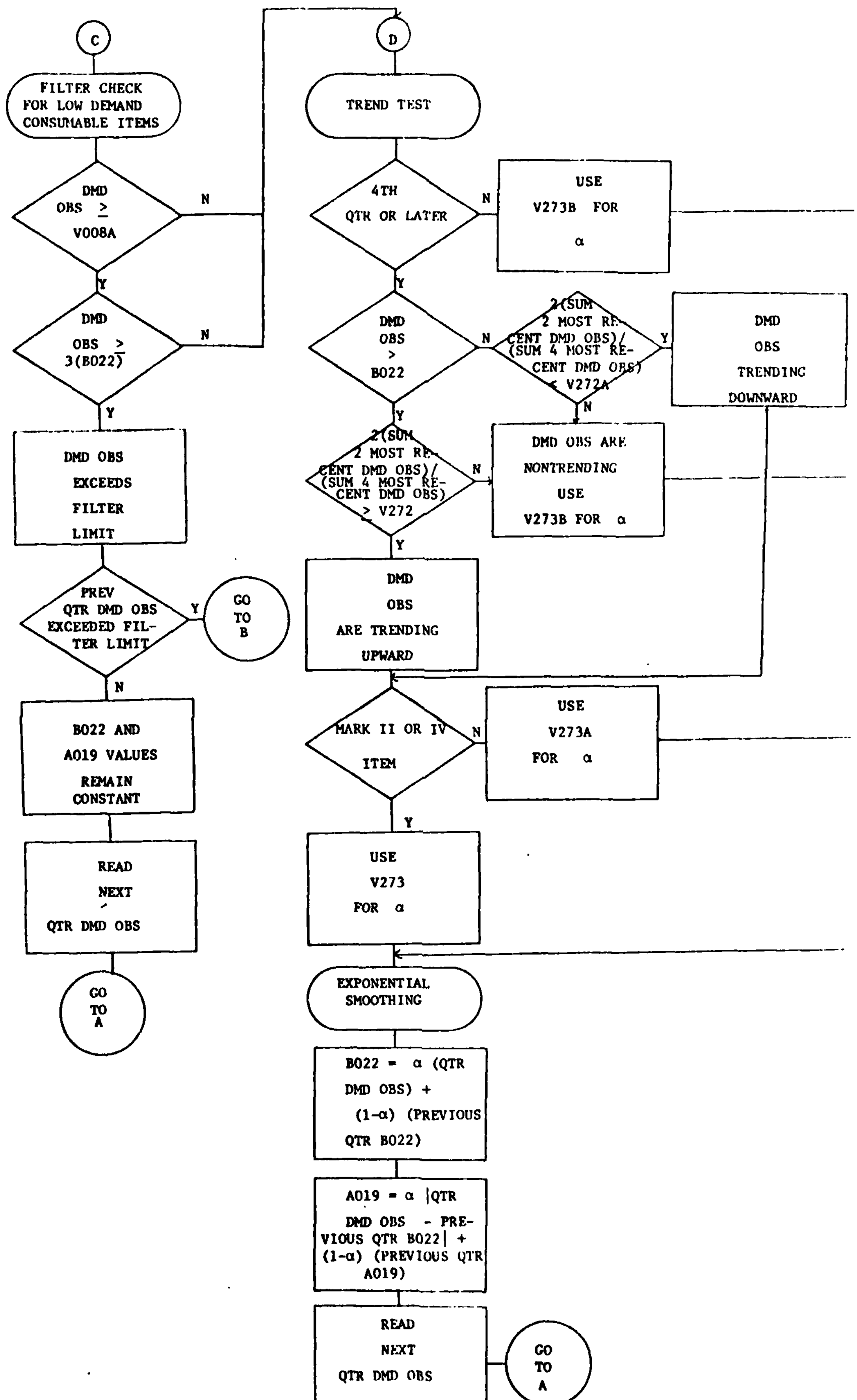
APPENDIX B: DEMAND FORECASTING FLOWCHART




C
FILTER CHECK FOR LOW DEMAND CONSUMABLE ITEMS
DMD OBS ≥ V008A
N
Y
DMD OBS ≥ 3(B022)
N
Y
DMD OBS EXCEEDS FILTER LIMIT
PREV QTR DMD OBS EXCEEDED FILTER LIMIT
Y
GO TO B
N
B022 AND A019 VALUES REMAIN CONSTANT
READ NEXT QTR DMD OBS
GO TO A
D
TREND TEST
4TH QTR OR LATER
N
USE V273B FOR α
Y
DMD OBS > B022
N
2(SUM 2 MOST RECENT DMD OBS)/(SUM 4 MOST RECENT DMD OBS) ≤ V272A
Y
DMD OBS TRENDING DOWNWARD
N
Y
2(SUM 2 MOST RECENT DMD OBS)/(SUM 4 MOST RECENT DMD OBS) ≥ V272
N
DMD OBS ARE NONTRENDING USE V273B FOR α
Y
DMD OBS ARE TRENDING UPWARD
MARK II OR IV ITEM
N
USE V273A FOR α
Y
USE V273 FOR α
EXPONENTIAL SMOOTHING
B022 = α (QTR DMD OBS) + (1-α) (PREVIOUS QTR B022)
A019 = α |QTR DMD OBS - PREVIOUS QTR B022| + (1-α) (PREVIOUS QTR A019)
READ NEXT QTR DMD OBS
GO TO A

APPENDIX C: SAMPLE TABLES

Table of Contents

SPCC Directional Analysis

1H Sample 1

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	4.985	57.9	80.98	993.5	N/A	7.048	.290	.983
V272 = 1.3 V272A = .7	5.131	57.4	81.17	1005.0	N/A	9.615	.294	1.130
V272 - 1.8 V272A = .2	4.935	57.9	79.96	1018.5	N/A	9.744	.295	1.168
V273 = .2 V273A = .2 V273B = 0	4.939	57.3	82.87	1039.0	N/A	8.004	.291	1.212
V273 = .4 V273A = .4 V273B = .2	5.269	59.1	79.68	972.5	N/A	7.024	.290	.937
V008 = 3 V008A = 1	4.951	58.1	80.92	988.0	N/A	9.239	.289	1.079
V008 = 9 V008A = 15	5.094	61.8	72.35	935.2	N/A	7.206	.290	1.002

SPCC Directional Analysis

1H Sample 2

PARAMETER VALUES	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	4.119	63.5	68.06	927.3	N/A	5.170	.106	.730
V272 = 1.3 V272A = .7	4.206	62.3	67.38	932.0	N/A	5.300	.110	.733
V272 = 1.8 V272A = .2	4.325	60.2	73.63	945.5	N/A	5.595	.110	.753
V273 = .2 V273A = .2 V273B = 0	4.313	59.1	74.28	969.7	N/A	5.477	.111	.809
V273 = .4 V273A = .4 V273B = .2	4.330	65.1	62.57	901.7	N/A	5.040	.106	.692
V008 = 3 V008A = 1	4.343	60.3	69.93	925.0	N/A	5.491	.110	.721
V008 = 9 V008A = 15	4.214	66.0	58.19	877.2	N/A	5.189	.106	.724

SPCC Directional Analysis

1H Sample 3

PARAMETER VALUES	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	4.575	57.2	71.01	917.2	N/A	20.115	.138	.664
V272 = 1.3 V272A = .7	4.471	55.0	75.21	920.5	N/A	19.934	.167	.672
V272 = 1.8 V272A = .2	4.499	54.0	75.43	930.5	N/A	20.608	.171	.700
V273 = .2 V273A = .2 V273B = 0	4.476	57.8	69.24	946.7	N/A	20.595	.164	.771
V273 = .4 V273A = .4 V273B = .2	4.680	59.7	66.94	899.0	N/A	21.254	.140	.641
V008 = 3 V008A = 1	4.495	53.4	81.57	926.5	N/A	20.110	.151	.680
V008 = 9 V008A = 15	4.572	59.1	69.65	850.2	N/A	25.533	.139	.697

SPCC Directional Analysis

1H Sample 4

PARAMETER VALUES	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	19.190	60.0	66.80	908.5	N/A	1.305	.014	.776
V272 = 1.3 V272A = .7	18.973	55.2	69.68	912.5	N/A	1.317	.015	.768
V272 = 1.8 V272A = .2	19.110	55.3	69.19	927.8	N/A	1.364	.015	.792
V273 = .2 V273A = .2 V273B = 0	19.259	56.1	72.85	926.0	N/A	1.750	.015	.949
V273 = .4 V273A = .4 V273B = .2	19.541	60.8	66.49	879.3	N/A	1.145	.013	.710
V008 = 3 V008A = 1	19.133	58.8	67.27	917.7	N/A	1.331	.015	.756
V008 = 9 V008A = 15	18.839	59.8	64.84	871.2	N/A	1.175	.014	.767

SPCC Directional Analysis

2H Sample 1

PARAMETER VALUES	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	89.771	51.1	81.28	728.0	1397.7	4.269	19.402	1.162
V272 = 1.3 V272A = .7	91.227	50.2	83.35	733.2	1421.0	4.269	19.403	1.177
V272 = 1.8 V272A = .2	91.081	49.4	85.56	742.7	1444.7	4.279	19.403	1.203
V273 = .2 V273A = .2 V273B = 0	90.881	46.5	85.05	736.2	1429.7	4.651	19.403	1.559
V273 = .4 V273A = .4 V273B = .2	90.586	51.6	78.26	704.7	1351.5	4.243	19.403	1.067
V008 = 3 V008A = 1	93.403	52.3	82.27	728.5	1328.5	4.276	19.403	1.191
V008 = 9 V008A = 15	91.240	51.6	82.46	731.5	1401.0	4.269	19.403	1.168

SPCC Directional Analysis

2H Sample 2

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	46.835	48.2	86.70	746.7	1536.7	.373	.018	.798
V272 = 1.3 V272A = .7	46.233	46.8	90.52	750.0	1525.7	.351	.021	.793
V272 = 1.8 V272A = .2	45.479	46.3	87.94	766.0	1580.5	.346	.018	.817
V273 = .2 V273A = .2 V273B = 0	46.130	49.8	81.28	757.0	1563.0	.393	.015	.989
V273 = .4 V273A = .4 V273B = .2	46.181	50.9	78.55	713.0	1495.2	.382	.020	.755
V008 = 3 V008A = 1	48.500	53.5	80.44	725.5	1401.2	.374	.018	.802
V008 = 9 V008A = 15	45.952	49.8	83.06	747.0	1555.2	.373	.018	.800

SPCC Directional Analysis

2H Sample 3

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	41.073	54.4	72.85	734.7	1343.7	.169	.052	.957
V272 = 1.3 V272A = .7	40.566	54.8	74.53	737.7	1409.2	.134	.043	.945
V272 = 1.8 V272A = .2	40.821	52.1	79.06	748.5	1412.7	.172	.051	.991
V273 = .2 V273A = .2 V273B = 0	42.134	54.9	74.39	743.7	1414.7	.277	.052	1.396
V273 = .4 V273A = .4 V273B = .2	40.248	57.5	71.10	719.5	1297.0	.164	.053	.847
V008 = 3 V008A = 1	42.066	52.7	78.48	731.0	1303.0	.169	.052	.930
V008 = 9 V008A = 15	40.768	57.0	70.98	731.7	1381.5	.139	.044	.933

ASO Directional Analysis

1R Sample 1

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	11.594	48.1	97.44	1313.0	N/A	99.878	.252	1.026
V272 = 1.3 V272A = .7	12.857	51.5	87.80	1298.5	N/A	99.905	.226	1.036
V272 = 1.1 V272A = .9	12.486	53.1	92.96	1291.0	N/A	100.661	.225	1.040
V272 = 1.8 V272A = .2	12.353	49.7	100.62	1335.0	N/A	101.910	.245	1.066
V273 = .3 V273A = .3 V273B = .1	12.065	44.2	107.18	1407.5	N/A	103.735	.280	1.081
V273 = .5 V273A = .5 V273B = .3	12.757	57.7	83.37	1227.0	N/A	97.094	.235	.984
V008 = 1 V008A = 2	12.653	54.6	91.17	1336.5	N/A	106.597	.301	1.066
V008 = 6 V008A = 25	12.254	52.3	88.27	1278.5	N/A	44.786	.196	.849

ASO Directional Analysis

1R Sample 2

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	9.756	44.1	108.60	1341.0	N/A	5.018	.037	.757
V272 = 1.3 V272A = .7	9.802	46.9	95.50	1324.0	N/A	4.506	.032	.756
V272 = 1.1 V272A = .9	10.429	49.0	97.10	1306.0	N/A	4.717	.034	.765
V272 = 1.8 V272 = .2	10.177	42.9	109.59	1364.0	N/A	4.953	.035	.778
V273 = .3 V273A = .3 V273B = .1	9.221	38.6	117.15	1440.0	N/A	5.173	.039	.775
V273 = .5 V273A = .5 V273B = .3	10.872	49.0	93.34	1277.0	N/A	4.699	.034	.731
V008 = 1 V008A = 2	11.171	50.4	94.75	1397.0	N/A	8.987	.047	.909
V008 = 6 V008 = 25	9.992	46.9	96.67	1313.5	N/A	5.328	.034	.762

ASO Directional Analysis

1R Sample 3

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	13.118	47.3	103.54	1205.0	N/A	18.206	.173	.696
V272 = 1.3 V272A = .7	13.897	51.4	88.92	1172.5	N/A	26.719	.182	.765
V272 = 1.1 V272A = .9	13.407	48.7	100.17	1184.0	N/A	25.583	.182	.759
V272 = 1.8 V272A = .2	13.203	48.6	98.10	1227.0	N/A	20.864	.175	.746
V273 = .3 V273A = .3 V273B = .1	12.567	42.6	114.05	1296.0	N/A	15.224	.172	.713
V273 = .5 V273A = .5 V273B = .3	13.582	52.9	90.61	1119.5	N/A	21.711	.180	.704
V008 = 1 V008A = 2	13.921	53.5	96.62	1256.0	N/A	33.678	.201	.766
V008 = 6 V008A = 25	13.675	51.0	86.10	1193.5	N/A	18.064	.173	.690

ASO Directional Analysis

IR Sample 4

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	20.121	48.5	109.86	1302.5	N/A	5.700	.292	.775
V272 = 1.3 V272A - .7	19.312	50.7	98.78	1291.0	N/A	5.968	.249	.796
V272 = 1.1 V272A = .9	18.541	50.7	88.80	1279.5	N/A	6.193	.284	.798
V272 = 1.8 V272A = .2	20.526	49.7	94.37	1321.5	N/A	6.487	.263	.818
V273 = .3 V273A = .3 V273B = .1	17.197	45.5	98.57	1412.5	N/A	5.920	.284	.824
V273 = .5 V273A = .5 V273B = .3	18.169	55.7	89.18	1232.0	N/A	5.318	.304	.752
V008 = 1 V008A = 2	21.881	57.0	81.66	1342.5	N/A	5.988	.224	.796
V008 = 6 V008A = 25	15.922	47.8	90.68	1239.5	N/A	5.283	.353	.750

SPCC Smoothing Weights Sensitivity Analysis

1H Sample 1
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	5.272	6[illegible] 2	68.78	898.2	N/A	8.462	.291	1.153
.4 .4 .2	5.869	66.9	60.20	841.5	N/A	8.859	.290	1.114
.5 .5 .3	6.199	67.8	59.95	799.7	N/A	9.413	.289	1.106
.6 .6 .4	6.855	70.2	55.27	883.2	N/A	10.047	.289	1.110
.7 .7 .5	7.179	69.3	57.46	1236.0	N/A	10.744	.288	1.119
.8 .8 .6	7.653	72.6	52.41	1785.5	N/A	11.508	.288	1.133
.9 .9 .7	8.265	74.5	51.24	1905.2	N/A	12.353	.287	1.148

SPCC Smoothing Weights Sensitivity Analysis

1H Sample 2
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	7.787	65.4	54.64	853.7	N/A	5.365	.106	.787
.4 .4 .2	9.443	71.3	46.14	800.0	N/A	5.496	.105	.775
.5 .5 .3	11.377	74.4	41.25	757.0	N/A	5.700	.105	.775
.6 .6 .4	13.132	75.5	41.95	730.7	N/A	5.967	.106	.778
.7 .7 .5	14.826	71.2	47.42	764.5	N/A	6.297	.107	.782
.8 .8 .6	16.835	77.4	37.19	1043.2	N/A	6.695	.109	.789
.9 .9 .7	18.167	78.0	37.68	1256.0	N/A	7.172	.111	.798

SPCC Smoothing Weights Sensitivity Analysis

1H Sample 3
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	4.769	60.9	60.83	806.5	N/A	25.577	.139	.732
.4 .4 .2	5.189	65.2	52.95	762.5	N/A	26.812	.140	.706
.5 .5 .3	5.732	64.6	60.49	716.5	N/A	27.486	.146	.696
.6 .6 .4	6.051	65.6	54.26	698.0	N/A	27.963	.152	.696
.7 .7 .5	6.356	73.4	41.53	896.5	N/A	28.500	.160	.702
.8 .8 .6	7.162	68.4	50.33	1202.0	N/A	29.194	.168	.709
.9 .9 .7	7.723	71.5	49.84	1359.7	N/A	30.180	.177	.722

SPCC Smoothing Weights Sensitivity Analysis

1H Sample 4
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	19.134	66.4	50.91	836.0	N/A	1.229	.014	.869
.4 .4 .2	19.685	66.3	53.13	781.0	N/A	1.230	.013	.824
.5 .5 .3	20.005	69.8	48.02	731.5	N/A	1.286	.013	.813
.6 .6 .4	26.838	72.1	46.79	802.5	N/A	1.358	.013	.814
.7 .7 .5	29.077	71.1	47.01	1218.5	N/A	1.439	.013	.818
.8 .8 .6	31.397	73.8	40.31	1495.5	N/A	1.531	.013	.827
.9 .9 .7	33.423	73.7	42.39	1702.5	N/A	1.634	.014	.839

SPCC Smoothing Weights Sensitivity Analysis

.2H Sample 1
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	91.459	55.1	76.64	725.7	1382.7	4.270	19.403	1.218
.4 .4 .2	92.413	56.3	74.64	700.2	1337.7	4.245	19.403	1.108
.5 .5 .3	92.659	57.5	71.13	688.5	1291.0	4.245	19.403	1.083
.6 .6 .4	93.107	59.0	69.12	684.7	1253.7	4.248	19.403	1.079
.7 .7 .5	94.204	61.5	62.49	743.0	1212.7	4.252	19.403	1.084
.8 .8 .6	95.449	63.0	62.99	724.0	1167.0	4.256	19.403	1.091
.9 .9 .7	95.830	63.1	64.99	762.2	1126.7	4.262	19.403	1.102

SPCC Smoothing Weights Sensitivity Analysis

2H Sample 2
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	46.476	51.2	78.26	746.5	1555.2	.373	.018	.816
.4 .4 .2	45.885	52.7	78.69	725.0	1519.2	.383	.020	.778
.5 .5 .3	47.871	55.0	76.39	704.2	1426.7	.399	.021	.774
.6 .6 .4	46.889	56.7	76.47	695.0	1382.2	.419	.023	.781
.7 .7 .5	48.938	62.1	67.42	711.7	1322.7	.443	.025	.792
.8 .8 .6	49.612	60.3	67.25	740.2	1300.2	.474	.027	.814
.9 .9 .7	50.911	63.6	65.03	729.2	1288.2	.509	.029	.837

SPCC Smoothing Weights Sensitivity Analysis

2H Sample 3
V008/A = MAX/MAX

PARAMETER VALUES [illegible] A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	39.658	56.2	70.38	738.5	1353.7	.139	.044	.946
.4 .4 .2	40.925	59.3	68.00	721.5	1333.5	.128	.042	.843
.5 .5 .3	42.593	59.5	65.42	709.0	1273.0	.126	.041	.816
.6 .6 .4	42.606	61.3	62.85	717.0	1210.5	.127	.041	.815
.7 .7 .5	44.999	63.2	60.06	732.2	1145.5	.131	.042	.822
.8 .8 .6	46.841	65.2	59.02	802.5	1114.0	.137	.042	.842
.9 .9 .7	48.404	68.1	56.80	811.2	1069.0	.146	.044	.864

ASO Smoothing Weights Sensitivity Analysis

1R Sample 1
V008/A = MAX/MAX
V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .4 .4 .2	13.820	55.7	83.59	1227.5	N/A	44.991	.171	.893
.5 .5 .3	15.885	58.7	77.94	1137.0	N/A	47.391	.175	.898
.6 .6 .4	15.544	63.2	66.97	1069.5	N/A	49.298	.180	.902
.7 .7 .5	17.303	63.9	71.78	1042.5	N/A	50.987	.188	.906
.8 .8 .6	18.529	66.3	72.69	995.0	N/A	52.657	.197	.913
.9 .9 .7	21.330	65.1	76.60	967.5	N/A	55.096	.208	.932

ASO Smoothing Weights Sensitivity Analysis

1R Sample 2
V008/A = MAX/MAX
V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .4 .4 .2	11.810	53.2	82.50	1227.5	N/A	5.464	.032	.847
.5 .5 .3	12.959	57.5	83.13	1135.0	N/A	5.707	.032	.856
.6 .6 .4	13.484	60.6	74.36	1081.0	N/A	5.966	.033	.865
.7 .7 .5	14.725	62.0	73.71	1025.0	N/A	6.242	.033	.873
.8 .8 .6	16.055	65.4	70.83	998.5	N/A	6.524	.034	.879
.9 .9 .7	16.865	66.5	74.28	984.5	N/A	6.822	.034	.884

ASO Smoothing Weights Sensitivity Analysis

1R Sample 3
V008/A = MAX/MAX
V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .4 .4 .2	15.148	55.1	82.07	1119.0	N/A	26.297	.178	.822
.5 .5 .3	16.875	61.5	81.16	1028.0	N/A	28.180	.184	.818
.6 .6 .4	17.382	62.9	75.13	975.0	N/A	30.294	.192	.823
.7 .7 .5	18.479	66.0	70.88	921.5	N/A	32.861	.202	.831
.8 .8 .6	19.513	64.7	77.46	876.5	N/A	35.637	.212	.845
.9 .9 .7	21.258	67.1	76.10	880.5	N/A	38.641	.224	.867

ASO Smoothing Weights Sensitivity Analysis

1R Sample 4
V008/A = MAX/MAX
V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .4 .4 .2	17.055	58.8	78.11	1217.5	N/A	5.749	.289	.800
.5 .5 .3	19.678	61.8	73.06	1126.5	N/A	5.844	.297	.802
.6 .6 .4	23.024	62.7	73.92	1060.5	N/A	6.016	.313	.809
.7 .7 .5	21.246	64.9	74.80	1019.5	N/A	6.262	.335	.819
.8 .8 .6	25.265	66.8	66.82	957.0	N/A	6.555	.364	.832
.9 .9 .7	27.194	66.3	72.53	949.0	N/A	6.890	.398	.850

SPCC Filter Constants Sensitivity Analysis

1H Sample 1
V273/A/B = .4/.4/.2

PARAMETER VALUES VOOR/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	5.269	59.1	79.68	972.5	N/A	7.024	.290	.937
9/15	5.381	65.6	67.14	889.2	N/A	7.218	.289	.953
15/30	5.463	66.3	62.67	863.8	N/A	7.230	.289	.964
25/100	5.553	65.2	64.07	852.0	N/A	7.671	.289	.999
MAX/MAX	5.869	66.9	60.20	841.5	N/A	8.859	.290	1.114

SPCC Filter Constants Sensitivity Analysis

1H Sample 2
V273/A/B = .4/.4/.2

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	4.330	65.1	62.57	901.7	N/A	5.040	.106	.692
9/15	4.469	68.7	51.08	825.0	N/A	5.172	.105	.705
15/30	4.541	69.2	50.92	822.2	N/A	4.960	.105	.683
25/100	4.518	69.3	51.70	811.0	N/A	4.945	.105	.687
MAX/MAX	9.443	71.3	46.14	800.0	N/A	5.496	.105	.775

SPCC Filter Constants Sensitivity Analysis

1H Sample 3
V273/A/B = .4/.4/.2

PARAMETER VALUES A008A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	4.680	59.7	66.94	899.0	N/A	21.254	.140	.641
9/15	4.787	62.5	68.55	797.5	N/A	26.760	.140	.672
15/30	5.172	60.6	62.85	787.2	N/A	26.756	.140	.667
25/100	5.153	61.0	57.78	772.0	N/A	26.754	.140	.684
MAX/MAX	5.189	65.2	52.95	762.5	N/A	26.812	.140	.706

SPCC Filter Constants Sensitivity Analysis

1H Sample 4
V273/A/B = .4/.4/.2

PARAMETER VALUES V008A	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	19.541	60.8	66.49	879.3	N/A	1.145	.013	.710
9/15	19.071	65.3	52.31	819.7	N/A	1.139	.013	.719
15/30	19.328	61.9	62.63	803.5	N/A	1.136	.013	.732
25/100	19.217	63.8	54.47	786.2	N/A	1.145	.013	.757
MAX/MAX	19.689	66.3	53.13	781.0	N/A	1.229	.014	.869

SPCC Filter Constants Sensitivity Analysis

2H Sample 1
V273/A/B = .4/.4/.2

PARAMETER VALUES V008A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	90.586	51.6	78.26	704.7	1351.5	4.243	19.403	1.067
9/15	90.494	51.6	78.72	758.2	1356.7	4.243	19.403	1.072
15/30	91.001	54.2	75.53	751.7	1343.5	4.244	19.403	1.080
25/100	90.750	56.8	74.32	755.0	1331.5	4.244	19.403	1.091
MAX/MAX	92.413	56.3	74.64	700.2	1337.7	4.245	19.403	1.108

SPCC Filter Constants Sensitivity Analysis

2H Sample 2
V273/A/B = .4/.4/.2

PARAMETER VALUES V008A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	46.181	50.9	78.55	713.0	1495.2	.382	.020	.755
9/15	45.700	53.5	77.68	773.0	1496.0	.382	.020	.762
15/30	46.086	53.9	74.62	773.5	1486.0	.383	.020	.771
25/100	46.732	52.9	76.09	773.5	1496.7	.383	.020	.774
MAX/MAX	45.885	52.7	78.69	725.0	1519.2	.383	.020	.778

SPCC Filter Constants Sensitivity Analysis

2H Sample 3
V273/A/B = .4/.4/.2

PARAMETER VALUES V008A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	40.248	57.5	71.10	719.5	1297.0	.164	.053	.847
9/15	40.730	57.8	67.13	760.2	1312.5	.128	.042	.826
15/30	41.403	58.6	67.99	767.2	1300.7	.128	.042	.835
25/100	40.883	56.9	67.22	759.7	1320.2	.128	.042	.835
MAX/MAX	40.925	59.3	68.00	721.5	133.5	.128	.042	.843

ASO Filter Constants Sensitivity Analysis

1R Sample 1
V272/A = 1.1/.9

PARAMETER VALUES VCOS/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 3/15	12.486	53.1	92.96	1291.0	N/A	100.661	.225	1.040
6/25	13.398	52.9	89.52	1254.0	N/A	45.036	.168	.882
15/30	14.284	56.9	84.02	1263.5	N/A	45.129	.173	.884
25/100	14.113	56.2	80.62	1231.5	N/A	45.088	.171	.890
MAX/MAX	13.820	55.7	83.59	1227.5	N/A	44.991	.171	.893

ASO Filter Constants Sensitivity Analysis

IR Sample 2
V272/A = 1.1/.9

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 3/15	10.429	49.0	97.10	1306.0	N/A	4.717	.034	.765
6/25	10.615	48.1	94.33	1286.5	N/A	5.323	.032	.789
15/30	10.811	52.2	88.70	1281.5	N/A	5.320	.031	.799
25/100	11.117	53.1	86.99	1235.0	N/A	5.324	.032	.813
MAX/MAX	11.810	53.2	82.50	1227.5	N/A	5.464	.032	.847

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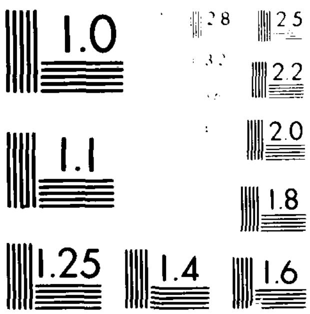
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ASO Filter Constants Sensitivity Analysis

1R Sample 3
V272/A = 1.1/.9

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 3/25	13.407	48.7	100.17	1184.0	N/A	25.583	.182	.759
6/25	15.873	56.1	80.40	1157.0	N/A	24.989	.180	.787
15/30	14.275	57.2	82.13	1132.0	N/A	25.649	.176	.764
25/100	14.751	55.9	81.30	1126.0	N/A	25.648	.177	.768
MAX/MAX	15.148	55.1	82.07	1119.0	N/A	26.297	.178	.822

ASO Filter Constants Sensitivity Analysis

1R Sample 4
V272/A = 1.1/.9

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 3/15	18.541	50.7	88.80	1279.5	N/A	6.193	.284	.798
6/25	16.318	53.0	81.34	1155.5	N/A	5.727	.283	.762
15/30	18.520	59.0	77.74	1246.0	N/A	5.753	.289	.786
25/100	17.855	59.7	70.37	1221.0	N/A	5.754	.289	.796
MAX/MAX	17.055	58.8	78.11	1217.5	N/A	5.749	.289	.800

APPENDIX D: STANDARD DEVIATIONS

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The Standard Deviations are shown in the upper left portion of the boxes and the mean values are shown in the lower right portion of the boxes: $S/\bar{X}$.

SPCC Directional Analysis

1W Values $S/\overline{X}$

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	7.324 / 8.217	2.8 / 59.7	6.43 / 71.71	36.7 / 936.6	N/A	8.162 / 8.410	.115 / .137	.138 / .786
V272 = 1.3 V272A = .7	7.196 / 8.195	3.4 / 57.5	6.16 / 73.36	42.4 / 942.5	N/A	8.013 / 9.042	.117 / .147	.207 / .826
V272 = 1.8 V272A = .2	7.266 / 8.217	2.8 / 56.9	4.46 / 74.55	42.7 / 955.6	N/A	8.262 / 9.328	.117 / .148	.213 / .853
V273 = .2 V273A = .2 V273B = 0	7.346 / 8.247	1.2 / 57.6	5.78 / 74.81	49.1 / 970.4	N/A	8.173 / 8.957	.115 / .145	.200 / .935
V273 = .4 V273A = .4 V273B = .2	7.401 / 8.454	2.7 / 61.2	7.44 / 68.92	40.8 / 913.1	N/A	8.772 / 8.616	.115 / .137	.131 / .745
V008 = 3 V008A - 1	7.273 / 8.051	3.0 / 57.7	7.39 / 74.92	32.7 / 939.3	N/A	8.054 / 9.043	.114 / .141	.183 / .809
V008 = 9 V008A = 15	7.115 / 8.180	3.1 / 61.7	6.21 / 66.26	36.4 / 883.5	N/A	10.800 / 9.776	.115 / .137	.139 / .798

SPCC Directional Analysis
2H Values $S / \overline{X}$

PARAMETER VALUES	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	26.609 / 59.226	3.1 / 51.2	6.98 / 80.28	9.5 / 736.5	99.6 / 1426.0	2.310 / 1.604	11.182 / 6.491	.182 / .972
V272 = 1.3 V272A = .7	27.758 / 59.342	4.0 / 50.6	8.01 / 82.80	8.7 / 740.3	64.1 / 1452.0	2.327 / 1.585	11.184 / 6.484	.193 / .972
V272 = 1.8 V272A = .2	27.771 / 59.127	2.9 / 49.3	4.60 / 84.19	12.1 / 752.4	89.1 / 1479.3	2.323 / 1.599	11.182 / 6.491	.193 / [illegible]
V273 = .2 V273A = .2 V273B = 0	27.064 / 59.715	4.2 / 50.4	5.41 / 80.24	10.5 / 745.6	81.6 / 1469.1	2.493 / 1.774	11.183 / 6.490	.294 / 1.315
V273 = .4 V273A = .4 V273B = .2	27.510 / 59.005	3.6 / 53.3	4.22 / 75.97	7.4 / 712.4	102.4 / 1381.2	2.295 / 1.596	11.181 / 6.442	.160 / .890
V008 = 3 V008A = 1	27.968 / 61.323	.6 / 52.8	1.90 / 80.40	2.8 / 728.3	51.0 / 1344.2	2.314 / 1.606	11.182 / 6.491	.198 / .974
V008 = 9 V008A = 15	27.765 / 59.320	3.7 / 52.8	6.81 / 78.83	8.9 / 736.7	95.2 / 1445.9	2.320 / 1.594	11.184 / 6.488	.186 / .967

ASO Directional Analysis
1R Values $S/\overline{X}$

PARAMETER VALUES	\$OH + \$DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case	4.529 / 13.648	2.0 / 47.0	5.65 / 104.86	59.2 / 1290.4	N/A	45.524 / 32.201	.112 / .189	.146 / .814
V272 = 1.3 V272A = .7	3.969 / 13.967	2.2 / 50.1	5.26 / 92.75	67.5 / 1271.5	N/A	44.914 / 34.275	.098 / .172	.133 / .838
V272 = 1.1 V272A = .9	3.451 / 13.666	2.0 / 50.4	4.95 / 94.76	55.2 / 1265.1	N/A	45.258 / 34.289	.107 / .181	.134 / .841
V272 = 1.8 V272A = .2	4.492 / 14.065	3.3 / 47.7	6.48 / 100.67	59.3 / 1311.9	N/A	46.131 / 33.554	.104 / .179	.146 / .852
V273 = .3 V273A = .3 V273B = .1	3.303 / 12.762	3.0 / 42.7	8.24 / 109.24	63.6 / 1389.0	N/A	47.701 / 32.513	.115 / .194	.162 / .848
V273 = .5 V273A = .5 V273B = .3	3.098 / 13.865	3.8 / 53.8	4.21 / 89.13	66.8 / 1213.9	N/A	43.970 / 32.206	.115 / .188	.129 / .793
V008 = 1 V008A = 2	4.784 / 14.907	2.7 / 53.9	6.66 / 91.05	58.1 / 1333.0	N/A	46.862 / 38.813	.106 / .193	.136 / .884
V008 = 6 V008A = 25	2.489 / 12.961	2.6 / 49.5	4.56 / 90.43	52.3 / 1268.8	N/A	18.612 / 18.365	.131 / .189	.066 / .763

SPCC Smoothing Weights Sensitivity Analysis

1H Values $^{S}/\ \overline{X}$
V008A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	6.726 / 9.241	2.6 / 63.7	7.82 / 58.79	38.4 / 846.6	N/A	10.698 / 10.158	.115 / .138	.187 / .885
.4 .4 .2	6.691 / 10.047	2.7 / 67.4	5.74 / 53.11	33.8 / 796.3	N/A	11.250 / 10.599	.115 / .137	.179 / .855
.5 .5 .3	6.631 / 10.828	4.1 / 69.2	9.42 / 52.43	36.4 / 751.2	N/A	11.500 / 10.971	.115 / .138	.179 / .848
.6 .6 .4	9.615 / 13.219	4.2 / 70.8	6.33 / 49.57	82.3 / 778.6	N/A	11.641 / 11.334	.115 / .140	.181 / .850
.7 .7 .5	10.527 / 14.360	1.7 / 71.3	6.65 / 48.36	235.4 / 1028.9	N/A	11.799 / 11.745	.115 / .142	.182 / .855
.8 .8 .6	11.333 / 15.762	3.7 / 73.1	7.45 / 45.06	328.1 / 1381.6	N/A	12.019 / 12.232	.115 / .145	.186 / .865
.9 .9 .7	12.019 / 16.895	2.7 / 74.4	6.39 / 45.29	301.1 / 1555.9	N/A	12.364 / 12.835	.115 / .147	.187 / .877

SPCC Smoothing Weights Sensitivity Analysis

2H Values $S/\bar{X}$
V008/A = MAX/MAX

PARAMETER VALUES V273/A/B	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .3 .3 .1	28.146 / 59.198	2.6 / 54.2	4.16 / 75.09	10.5 / 736.9	108.9 / 1430.5	2.320 / 1.594	11.184 / 6.488	.205 / .993
.4 .4 .2	28.403 / 59.741	3.3 / 56.1	5.40 / 73.78	13.4 / 715.6	106.0 / 1396.8	2.307 / 1.585	11.184 / 6.488	.175 / .910
.5 .5 .3	27.509 / 61.041	2.2 / 57.3	5.49 / 70.98	10.7 / 700.6	84.0 / 1330.2	2.303 / 1.590	11.184 / 6.488	.168 / .891
.6 .6 .4	28.002 / 60.867	2.3 / 59.0	4.07 / 67.48	16.5 / 698.9	89.3 / 1282.1	2.300 / 1.598	11.184 / 6.489	.163 / .892
.7 .7 .5	27.342 / 62.714	.8 / 62.3	3.75 / 63.32	15.9 / 729.0	89.5 / 1227.0	2.295 / 1.609	11.183 / 6.490	.161 / .899
.8 .8 .6	27.296 / 63.966	2.5 / 62.8	4.12 / 63.09	41.4 / 755.6	95.9 / 1193.7	2.287 / 1.622	11.182 / 6.491	.152 / .916
.9 .9 .7	26.687 / 65.048	2.8 / 64.9	4.74 / 62.27	41.3 / 767.5	113.6 / 1161.3	2.279 / 1.639	11.181 / 6.492	.146 / .934

ASO Smoothing Weights Sensitivity Analysis

IR Values $S/\bar{X}$
V008/A = MAX/MAX
V272/A = 1.1/.9

PARAMETER VALUES V273/A/B	•$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case .4 .4 .2	2.209 / 14.459	2.3 / 55.7	2.43 / 81.57	52.8 / 1197.9	N/A	18.948 / 20.625	.105 / .168	.040 / .841
.5 .5 .3	2.773 / 16.349	2.1 / 59.9	4.40 / 78.82	52.6 / 1106.6	N/A	20.076 / 21.781	.109 / .172	.043 / .844
.6 .6 .4	4.099 / 17.359	1.2 / 62.4	3.78 / 72.60	48.4 / 1046.5	N/A	21.003 / 22.894	.115 / .180	.042 / .850
.7 .7 .5	2.706 / 17.938	1.7 / 64.2	1.78 / 72.79	54.6 / 1002.1	N/A	21.847 / 24.066	.124 / .190	.040 / .857
.8 .8 .6	3.898 / 19.841	.9 / 65.8	4.42 / 71.95	56.7 / 956.8	N/A	22.797 / 25.343	.135 / .202	.036 / .867
.9 .9 .7	4.238 / 21.662	.8 / 66.3	1.856 / 74.88	45.6 / 945.4	N/A	24.058 / 26.862	.149 / .216	.035 / .883

SPCC Filter Constants Sensitivity Analysis

1H Values $S/\overline{X}$
V273/A/B = .4/.4/.2

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	7.401 / 8.455	2.7 / 61.2	7.44 / 68.92	40.8 / 913.1	N/A	8.772 / 8.616	.115 / .137	.131 / .745
9/15	7.106 / 8.427	2.5 / 65.5	9.36 / 59.77	39.4 / 832.9	N/A	11.408 / 10.072	.115 / .137	.129 / .762
15/30	7.145 / 8.626	4.0 / 64.5	5.90 / 59.77	33.0 / 819.2	N/A	11.437 / 10.021	.115 / .137	.138 / .762
25/100	7.084 / 8.610	3.5 / 64.8	5.33 / 57.01	35.1 / 805.3	N/A	11.396 / 10.151	.115 / .137	.149 / .782
MAX/MAX	6.691 / 10.047	2.7 / 67.4	5.74 / 53.11	33.8 / 796.3	N/A	11.250 / 10.599	.115 / .137	.179 / .855

SPCC Filter Constants Sensitivity Analysis

2H Values $S/\overline{X}$
V273/A/B = .4/.4/.2

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 6/2	27.510 / 59.005	3.6 / 53.3	4.22 / 75.97	7.4 / 712.4	102.4 / 1381.2	2.295 / 1.596	11.181 / 6.492	.160 / .890
9/15	27.409 / 58.975	3.2 / 54.3	6.41 / 74.51	8.0 / 763.8	95.8 / 1388.4	2.306 / 1.584	11.184 / 6.488	.226 / .839
15/30	27.384 / 59.497	2.6 / 55.6	4.10 / 72.71	11.2 / 764.1	97.0 / 1376.7	2.306 / 1.585	11.184 / 6.488	.163 / .895
25/100	27.260 / 59.455	2.3 / 55.5	4.70 / 72.54	9.4 / 765.2	98.8 / 1382.8	2.306 / 1.585	11.184 / 6.488	.168 / .900
MAX/MAX	28.403 / 59.741	3.3 / 56.1	5.40 / 73.78	13.4 / 715.6	106.0 / 1396.8	2.307 / 1.585	11.184 / 6.488	.175 / .910

ASO Filter Constants Sensitivity Analysis

IR Values $^{S}/_{\overline{X}}$
V272/A = 1.1/.9

PARAMETER VALUES V008/A	$OH + $DI (MIL)	SMA %	ADD	#PI	#RA	MSE (MIL)	VAD MSE (MIL)	CU SUM
Base Case 3/15	3.451 / 13.711	2.0 / 50.4	4.95 / 94.76	55.2 / 1265.1	N/A	45.258 / 34.289	.107 / .181	.134 / .841
6/25	2.626 / 14.051	3.3 / 52.5	6.69 / 86.39	67.1 / 1213.3	N/A	18.890 / 20.268	.103 / .166	.046 / .802
15/30	3.155 / 14.473	2.9 / 56.3	4.54 / 83.15	67.4 / 1230.8	N/A	18.982 / 20.463	.106 / .167	.053 / .808
25/100	2.763 / 14.459	2.7 / 56.2	6.92 / 79.82	51.9 / 1203.4	N/A	18.963 / 20.454	.105 / .167	.052 / .817
MAX/MAX	2.209 / 14.458	2.3 / 55.7	2.43 / 81.57	52.8 / 1197.9	N/A	18.948 / 20.625	.105 / .168	.040 / .841

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13. ABSTRACT

This study estimates parameter values pertaining to the UICP (Uniform Inventory Control Program) model for forecasting demand and the MAD (Mean Absolute Deviation) of demand. More specifically, the filter constants, trend significance levels and smoothing weights are evaluated using the 5A (Aviation Afloat and Ashore Allowance Analyzer) wholesale inventory simulator. Alternative values were systematically selected for the filter constants, trend significance levels and smoothing weights to be applied to a data base of actual demands for determining which parameter values generate the most effective demand forecast. Effectiveness is judged by the fillowing criteria: inventory investment, performance, workload and demand forecast accuracy. As a result of the simulations, the following recommendations are made:

SPCC -

- increase the filter constants (V008, V008A) from 6 and 2 to 9 and 15
- retain the current trend significance levels (V272, V272A) of 1.1 and .9
- increase the exponential smoothing weights (V273, V273A, V273B) from .3, .3 and .1 to .4, .4 and .2

ASO -

- increase the filter constants from 3 and 15 to 6 and 25
- replace the trend significance levels of 1.5 and .99 with 1.1 and .9
- retain the current exponential smoothing weights of .4, .4 and .2

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